Volume 31 DECEMBER, 1947 Number 12

BULLETIN
of the
American Association *of* Petroleum Geologists

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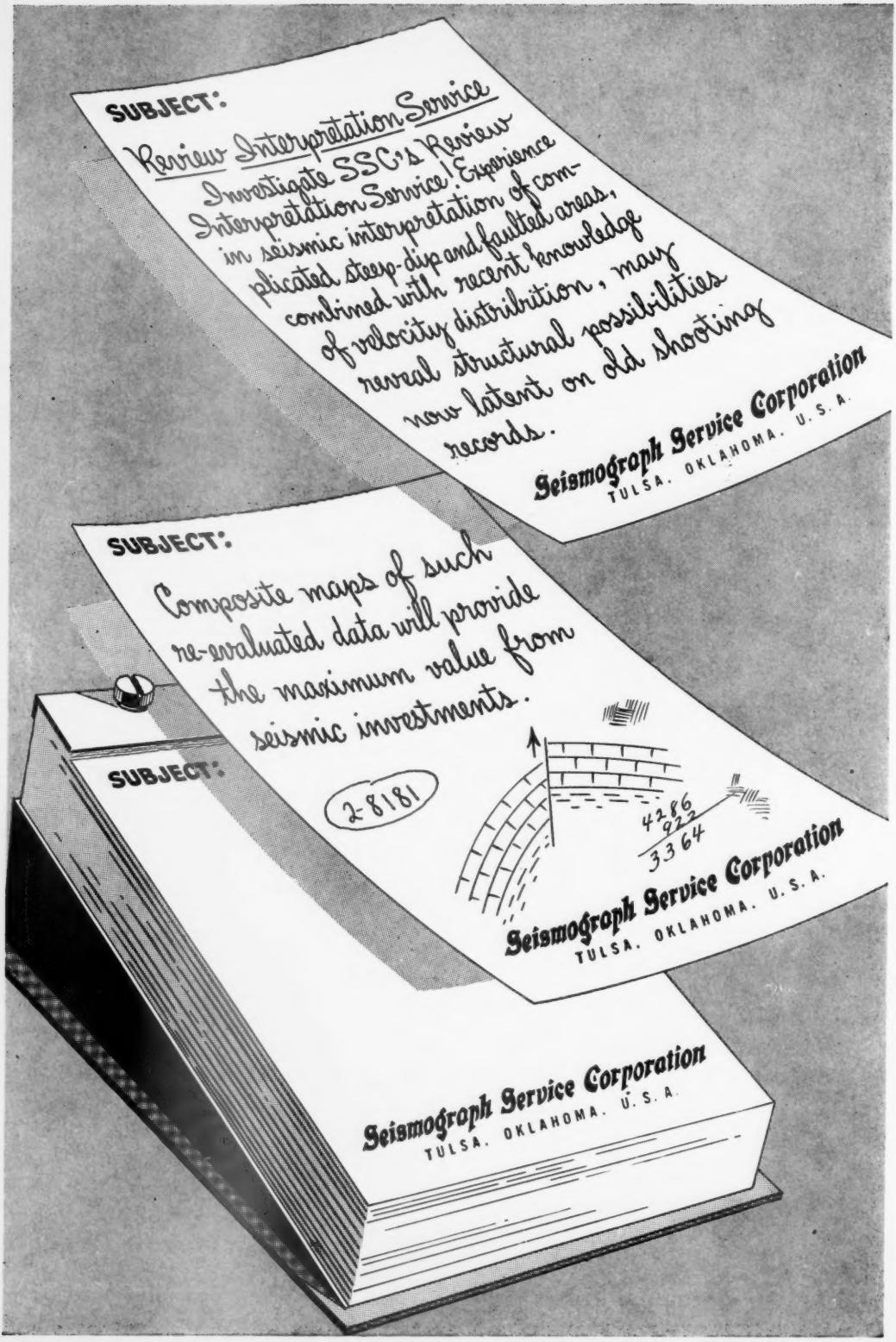
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BRITISH AGENT: Thomas Murby & Co., 40 Museum Street, London, W. C. 1.

SUBSCRIPTION PRICE to non-members is $15 per year (separate numbers, $1.50), prepaid to addresses in the United States; outside the United States, $15.40.

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Entered as second-class matter at the Post Office at Tulsa, Oklahoma, and at the Post Office at Menasha Wisconsin, under the Act of March 3, 1879. Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized March 9, 1913.

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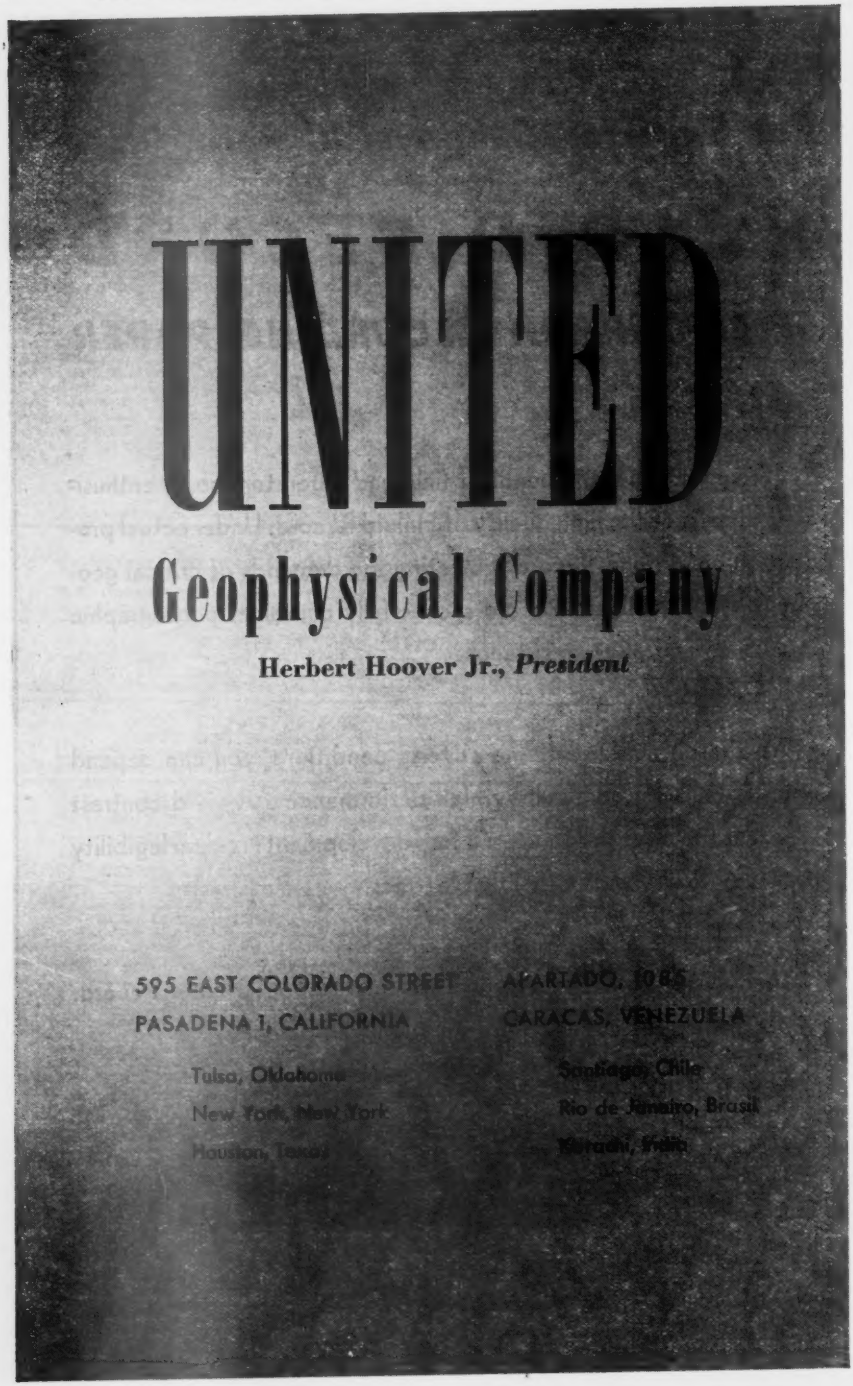
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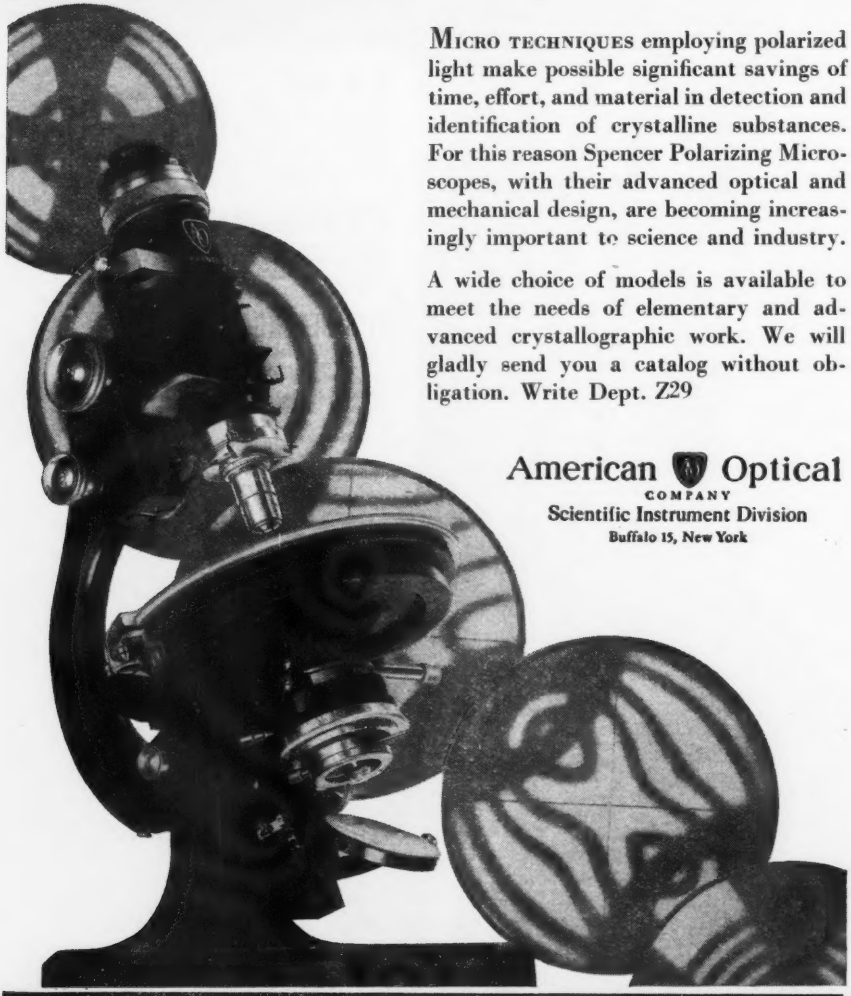

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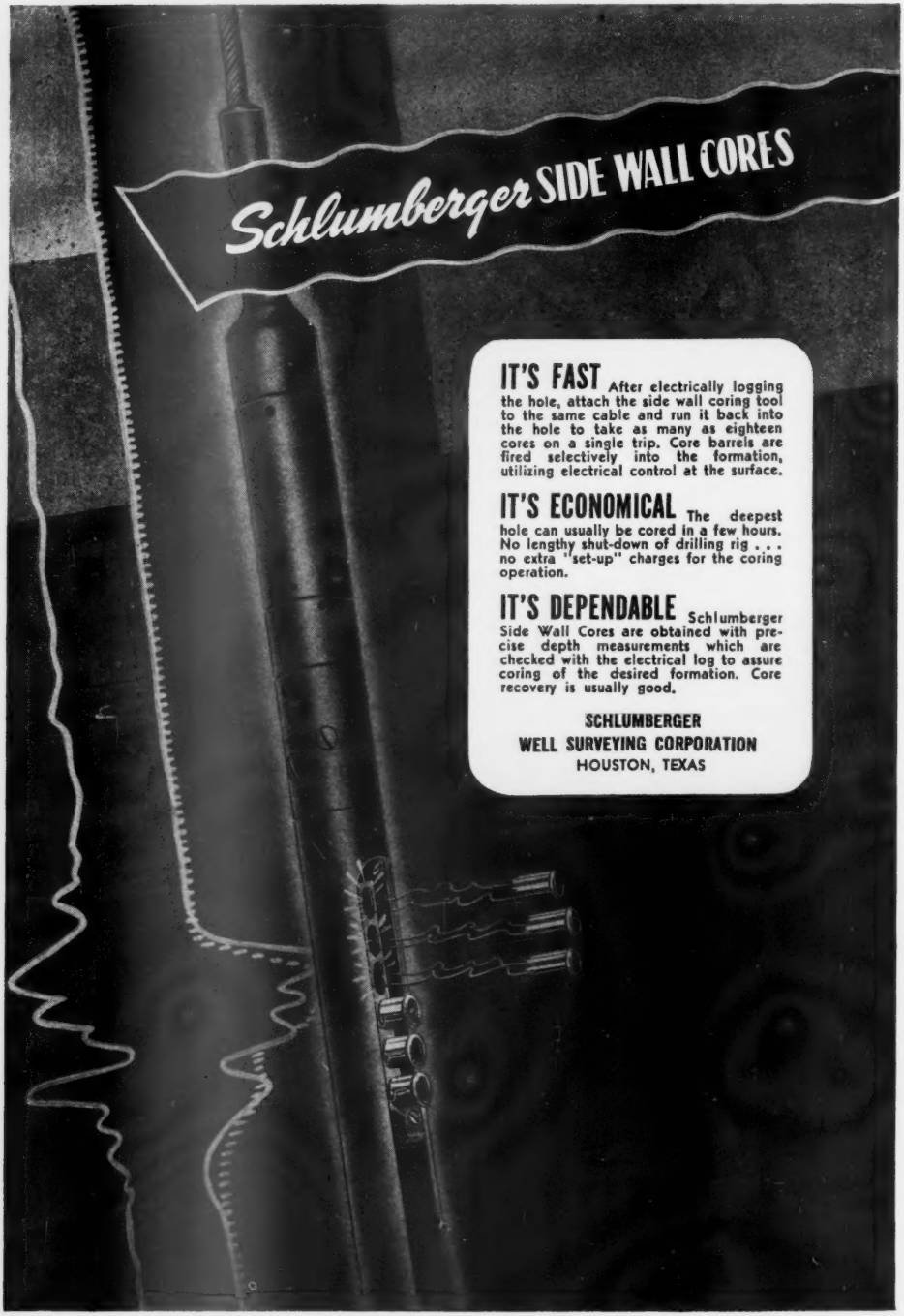
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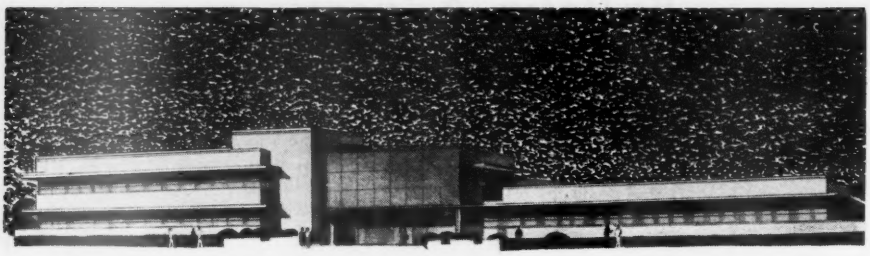

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DECEMBER, 1947

OIL FIELDS OF GREATER OFICINA AREA CENTRAL ANZOATEGUI, VENEZUELA[1]

H. D. HEDBERG,[2] L. C. SASS,[3] H. J. FUNKHOUSER[4]
New York and Venezuela

ABSTRACT

The oil fields of the Greater Oficina area are situated in the south-central part of the state of Anzoategui in the midst of the vast interior plains of Eastern Venezuela. Since the completion of the discovery well in 1937, 16 fields with a total of 512 wells have been drilled, resulting in a production of more than 127 million barrels of oil to January 1, 1946.

The region is covered by Quaternary and uppermost Tertiary deposits, and surface indications of structure are meager. No seepages are known within a distance of more than 100 kilometers. The discovery well was located on the basis of torsion-balance and refraction-seismograph work, and subsequent development has been guided principally by geophysical, structure-drill, and subsurface geological work.

The section encountered by wells in the Greater Oficina area is as follows.

[1] Manuscript received, April 12, 1947.

[2] Gulf Oil Corporation, New York. Formerly with Mene Grande Oil Company, Caracas, Venezuela.

[3] Mene Grande Oil Company, Barcelona, Venezuela.

[4] Mene Grande Oil Company, Caracas, Venezuela.

Acknowledgment.—Naturally the information included in the present report on the oil fields of the Greater Oficina area has been accumulated gradually during the past 13 years only through the combined efforts of the many geologists, geophysicists, and engineers who have worked in this area. The writers wish particularly to acknowledge the work of P. E. Nolan, chief geologist of the Mene Grande Oil Company, and George Lockett, now district geologist, in the development of information on this area. Among the many other geologists who have contributed, particular mention may be made of the following.

Stratigraphy: W. F. Auer, C. W. Flagler, Georges Pardo, Augustin Pyre, R. B. Van Buren
Subsurface geology: Grady Davis, Henry Guntz, Carlos Vogeler
Core and fluid analysis: G. E. Manger, Paul Otamendi
Surface geology: Roy Wilson
Topography: Charles Neff
General: C. A. Baird, E. E. Brossard

Without attempting to give specific names, the writers also wish to acknowledge the important contributions made by the geological staffs of the New York and Pittsburgh offices of the Gulf Oil Corporation and by the various members of the Gulf Research and Development Company who have worked on the geophysics of this area.

This report is published with the approval of C. M. Crebbs, president of the Mene Grande Oil Company, and Hoyt Sherman, general manager of that company. Permission for publication has also been received from the Creole Petroleum Corporation, joint owner with the Mene Grande of many of the concessions in this area, and from the Socony Vacuum of Venezuela, operators of a part of the West Guara field.

Mesa formation (Pleistocene). 0–500 feet thick
Sacacual group (upper Miocene-Pliocene). 400–3,000 feet thick
Freites formation (middle Miocene). 1,100–2,000 feet thick
Oficina formation (Oligocene-Miocene). 2,000–4,000 feet thick
Unconformity
Temblador formation (Cretaceous). 500–1,500 feet thick
Unconformity
Basement igneous and metamorphic rocks

The Greater Oficina area is a segment of the southern limb of the Eastern Venezuelan structural basin. Dips are very gentle (less than 5°) throughout the area and there is little folding. Accumulation is controlled largely by normal faults constituting barriers to migration of oil southward and westward up the regional dip of the basin. Stratigraphic pinch-outs are locally important adjuncts to accumulation.

Production is from sands in the Oficina formation. There are 65 distinct, productive sands in 46 different accumulation segments, constituting 340 separate, productive reservoirs. Producing depths range from 4,000 to 7,000 feet. Total surface productive area to date amounts to more than 25,000 acres. Net productive sand thicknesses in individual wells may amount to as much as 550 feet.

Reservoir pressures show a regular straight-line increase with depth within the Oficina formation in accordance with the calculated hydrostatic gradient but are slightly out of equilibrium with hydrostatic pressures in near-surface sands. The temperature gradient in the area is about 51 feet per degree Fahrenheit. Oil gravities range from 8° to 57°; the oil being produced averages about 34° API. Gravities in general are heavier with depth. The Oficina oils are largely of intermediate base. Some reservoirs contain oil with a wax content up to 15 per cent by weight. Almost all reservoirs have gas caps but few produce gas only. Formation waters vary in salinity from about 4,500 parts per million in the shallow producing zones to 22,000 parts per million in the deep zones.

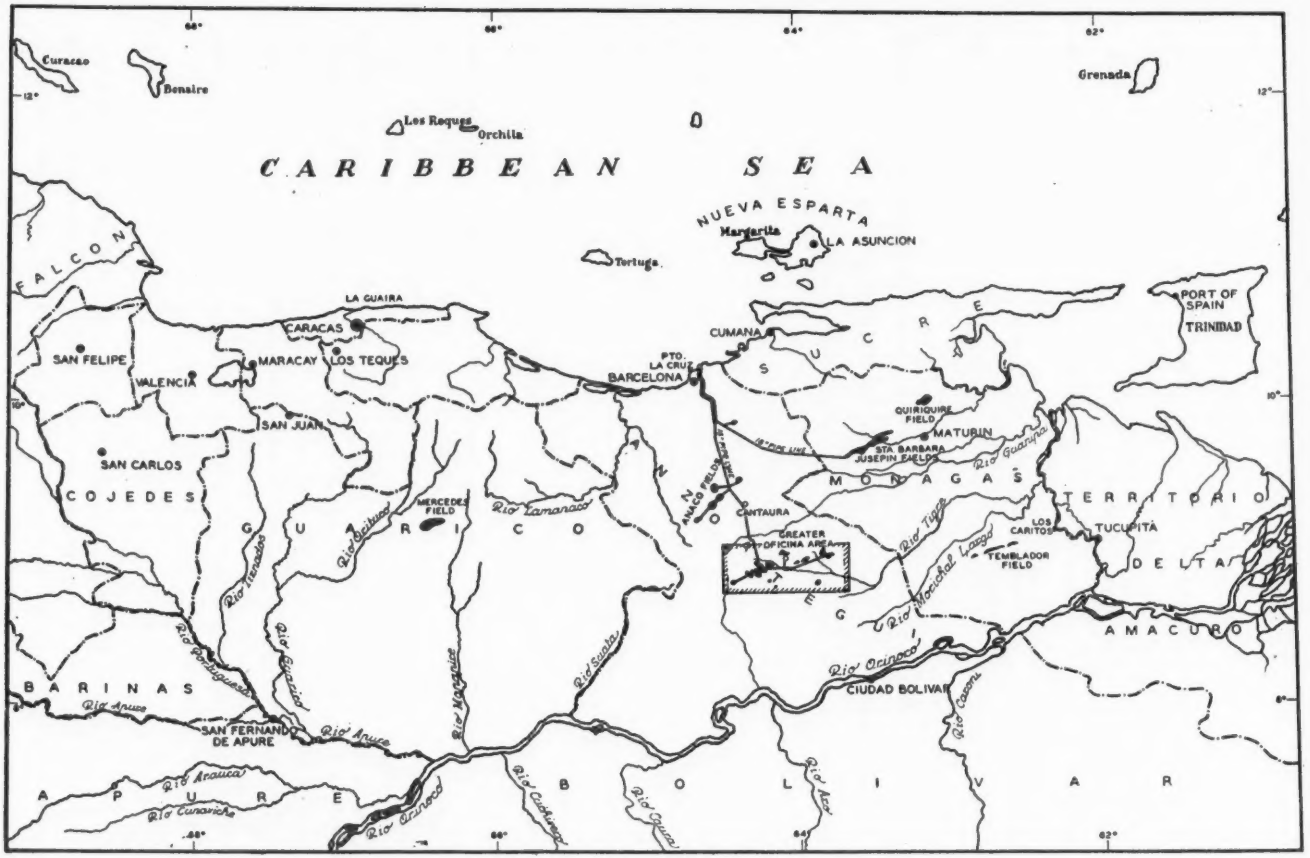
It is believed that the oil produced in the Greater Oficina fields originated within the Oficina formation and in close proximity stratigraphically and geographically to the reservoirs in which it is now found. There is definite evidence, however, of a certain amount of lateral migration within the reservoir sands up the regional dip of the Eastern Venezuelan basin.

Dual- and triple-zone completions are common practice but only a single sand is opened in any one zone. Well spacing is on the equilateral-triangle system and varies from 14 to 42 acres or more, according on local factors. The relatively flat open terrane allows skidding of rigs and derricks from one location to the next. Pressure-maintenance and secondary-recovery projects are in prospect. The outlet of the fields is through a 155-kilometer pipeline to the Caribbean coast at Puerto la Cruz.

INTRODUCTION

The Oficina No. 1 wildcat well of the Mene Grande Oil Company, C.A., was spudded on February 23, 1933, in the south-central part of the state of Anzoategui, 107 kilometers (67 miles) from the nearest oil seepage and 170 kilometers (106 miles) from the nearest producing oil field (Quiriquire). This was the first well to be drilled in the vast interior plains of Eastern Venezuela, and its successful results opened the southern and central parts of the great Eastern Venezuela basin to a drilling campaign which is still vigorously continuing and has already led to the production of more than 175,000,000 barrels of oil.

Most of the production to date in this region has come from a group of fields in the general vicinity of the discovery well, constituting the so-called Greater Oficina producing area. These fields extend along a belt 80 kilometers (50 miles) in length through the southern part of the district of Freites and the northeastern part of the district of Miranda, state of Anzoategui (Fig. 1). In all, 512 wells have been drilled to date in this area, resulting in a production of more than 127,000,000 barrels of oil (January 1, 1946). Current production is slightly more than 100,000 barrels per day.


Curaçao
Bonaire
Los Roques
Orchila
CARIBBEAN SEA
Grenada
NUEVA ESPARTA
Margarita
LA ASUNCION
Tortuga
FALCON
LA GUAIRA
CARACAS
SAN FELIPE
VALENCIA
MARACAY
LOS TEQUES
SAN JUAN
SAN CARLOS
COJEDES
PTO. LA CRUZ
BARCELONA
CUMANA
SUCRE
PORT OF SPAIN
TRINIDAD
QUIRIQUIRE FIELD
MATURIN
STA BARBARA
JUSEPIN FIELDS
MORAGAS
TERRITORIO
DELTA
AMACURO
GUARICO
MERCEDES FIELD
ANACO FIELDS
CANTAURA
GREATER OFICINA AREA
LOS CARITOS
TUCUPITA
TEMBLADOR FIELD
Río Tigre
Río Morichal Largo
Río Guanipa
Río Tamanaco
Río Orinoco
CIUDAD BOLIVAR
Río Caroní
BARINAS
Río Apure
SAN FERNANDO DE APURE
APURE
Río Araucá
Río Cunaviche
Río Arauca
BOLIVAR
Río Acoi
Río Caratal
Río Portuguesa
Río Guárico
Río Santa Rita
Río Manapire
Río Cabriales
Río Tinaco
Río Zuata
Río Cojedes
Río Pao
Río Unare
Río Aragua
Río Neverí
Río Cariaco
Río Guarapiche
Río Amana
Río Morichal
Río Grande
Río Yuruari
Río Caura
Río Paragua
Río Caroní
Río Icabarú
Río Caroní

MAJOR FEATURES

Outstanding features of the fields of the Greater Oficina area are the following.

1. Gentle regional dip (less than 5°)
2. Very little folding
3. Tension faulting common with planes dipping at about 45°
4. Numerous relatively small pools scattered over a broad area
5. Fault-trap type of accumulation, but pinch-out on one or two sides in some places an important adjunct
6. Multiple productive sands
7. All production from Oligocene-Miocene Oficina formation
8. Moderate producing depths (4,000–7,000 feet)
9. Oil gravities ranging from 8° to 57° API (Average gravity of oil produced in 1945 was 33.9° API)
10. Intermediate base oils, in general
11. Some wax oils (up to 15 per cent wax by weight)
12. Oil gravities are generally heavier with increasing depth, although there are numerous exceptions
13. Almost all reservoirs have gas caps, but very few show only gas
14. Dual- and triple-zone completions common
15. Flat topography permits skidding of rigs and derricks

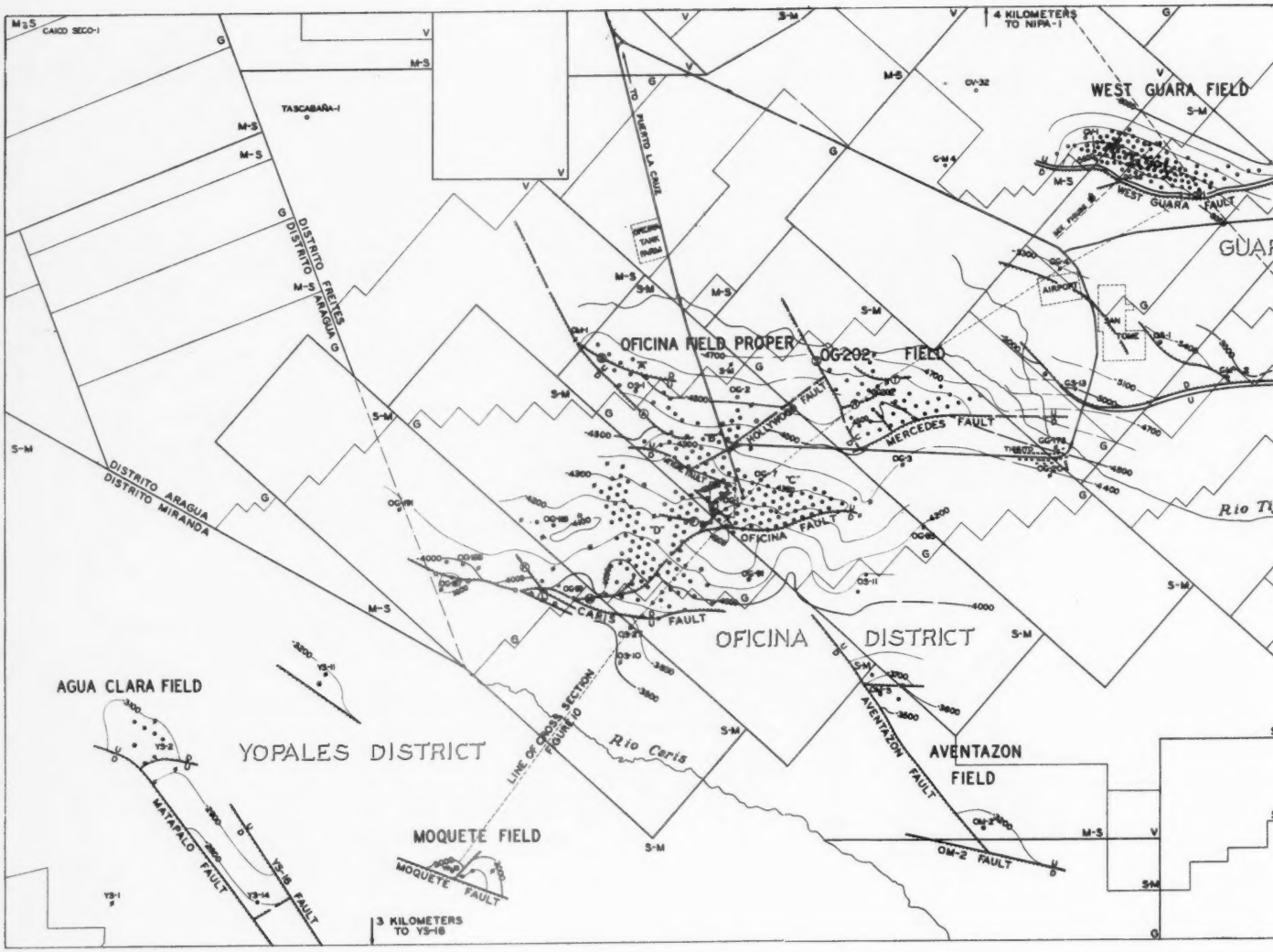
ACREAGE OWNERSHIP AND NOMENCLATURE OF DISTRICTS, FIELDS, AND WELLS

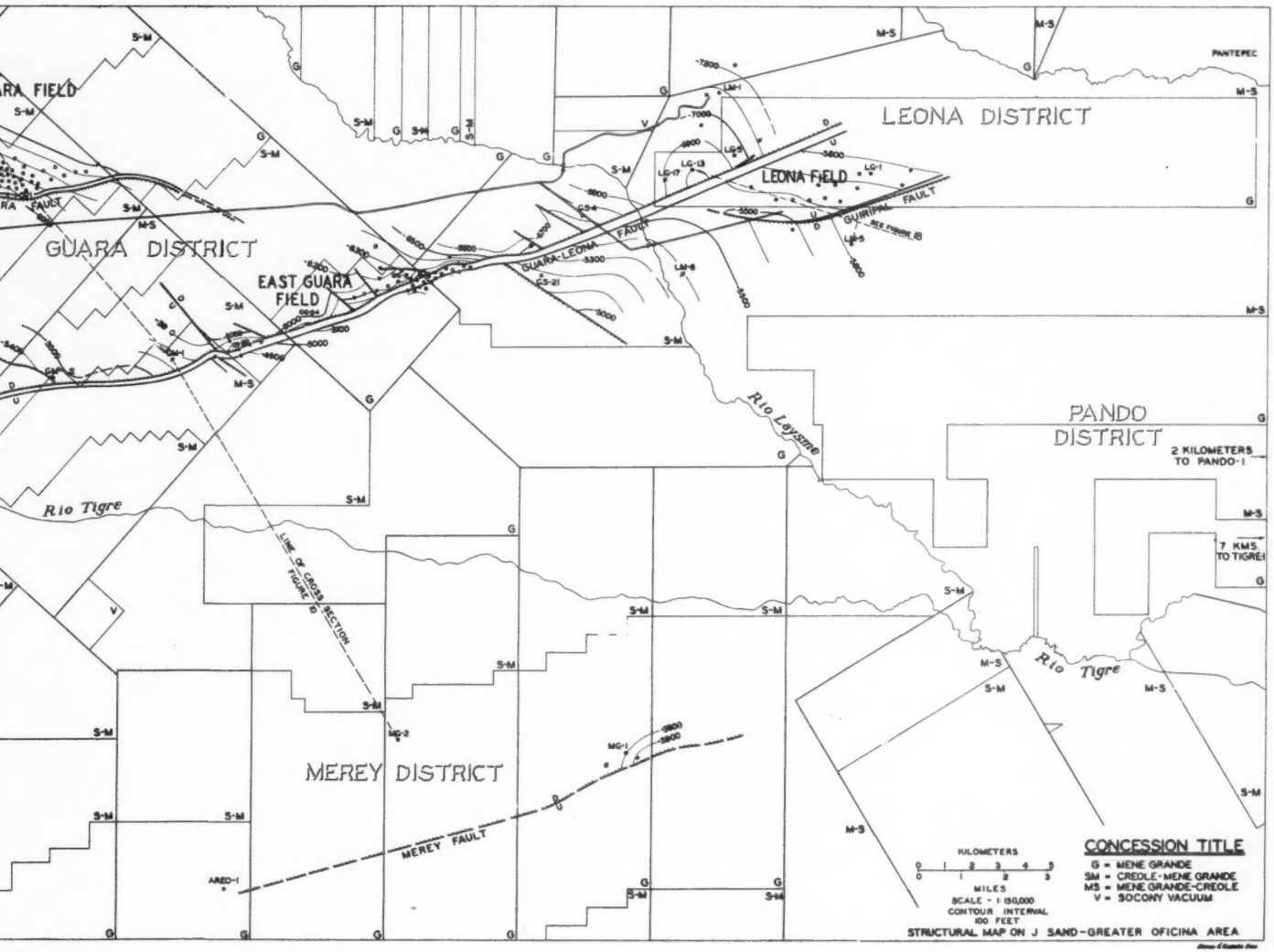
Most of the concessions in the Greater Oficina area are owned by the Mene Grande Oil Company, C.A.(subsidiary of the Gulf Oil Corporation), or jointly by the Creole Petroleum Corporation (subsidiary of the Standard Oil Company of New Jersey) and the Mene Grande Oil Company. In the case of the jointly held concessions, all of which are operated by Mene Grande, some titles are in the name of Creole and some in the name of Mene Grande. A lesser part of the area is held by the Socony Vacuum Oil Company of Venezuela. There is no open acreage remaining.

For operating convenience, the Greater Oficina producing area has been divided into several *districts*, each of which contains one or more *fields* (Fig. 2). Individual fields may consist of several *segments* and each segment in turn may include numerous *reservoirs*. Wells in the Mene Grande and joint Mene Grande-Creole concessions are designated by letters indicating the district and ownership title of the concession and are numbered consecutively in order of drilling within each district. Socony wells drilled to date have been given the letter designation GV and are numbered according to location rather than by chronological order. Table I classifies the fields of the Greater Oficina area by districts, gives the owners and well designations for each field, and summarizes the number of wells drilled in each district.

DISCOVERY

The location of Oficina No. 1, the discovery well of the area, was based on a combination of torsion-balance and refraction-seismograph data, showing at this point a structural disturbance in the regional northward dip of sedimentary rocks


CAICO SECO-1
TASCABAÑA-1
4 KILOMETERS TO NIPA-1
WEST GUARA FIELD
WEST GUARA FAULT
AIRPORT
TOWN
OFICINA FIELD PROPER
OG202 FIELD
HOLLYWOOD FAULT
MERCEDES FAULT
OFICINA FAULT
CARIS FAULT
DISTRITO ARAGUA
DISTRITO MIRANDA
DISTRITO FREITES
DISTRITO ARAGUA
TO PUERTO LA CRUZ
OFICINA DISTRICT
YOPALES DISTRICT
AGUA CLARA FIELD
MATAPALO FAULT
YS-16 FAULT
MOQUETE FIELD
MOQUETE FAULT
LINE OF CROSS SECTION FIGURE 10
Rio Caris
AVENTAZON FIELD
AVENTAZON FAULT
OM-2 FAULT
3 KILOMETERS TO YS-16


LEONA DISTRICT
LEONA FIELD
GUIRIPAL FAULT
GUARA DISTRICT
EAST GUARA FIELD
GUARA-LEONA FAULT
PANDO DISTRICT
2 KILOMETERS TO PANDO-1
7 KMS. TO TIGRE
Rio Tigre
Rio Tigre
Rio Lajsme
MEREY DISTRICT
MEREY FAULT
LINE OF CROSS SECTION FIGURE 10
PANTEPEC
CONCESSION TITLE
G = MENE GRANDE
SM = CREOLE-MENE GRANDE
MS = MENE GRANDE-CREOLE
V = SOCONY VACUUM
KILOMETERS
MILES
SCALE - 1:50,000
CONTOUR INTERVAL 100 FEET
STRUCTURAL MAP ON J SAND-GREATER OFICINA AREA

C

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19

19

TABLE I

CLASSIFICATION OF OIL FIELDS IN GREATER OFICINA AREA
BY DISTRICTS & OWNERSHIP

DISTRICT	FIELD	OWNERSHIP	WELL DESIGNATION
Yopales	YS-1	Creole-Mene Grande	YS
	Agua Clara(YS-2)	Creole-Mene Grande	YS
	YS-11	Creole-Mene Grande	YS
	YS-14	Creole-Mene Grande	YS
	Moquete(YS-15)	Creole-Mene Grande	YS
Oficina	Oficina Proper	Mene Grande	OG
		Creole-Mene Grande	OS
		Mene Grande-Creole	OM
	OG-202	Mene Grande	OG
	Aventazon	Mene Grande-Creole	OM
		Creole-Mene Grande	OS
Guara	GS-13	Creole-Mene Grande	GS
	West Guara	Mene Grande	*WGG
		Creole-Mene Grande	WGS
		Socony Vacuum	WGV
	GM-2	Mene Grande-Creole	GM
	East Guara	Mene Grande	*EGG
		Creole-Mene Grande	EGS
		Mene Grande-Creole	EGM
	GS-21	Creole-Mene Grande	GS
Leona	Leona	Mene Grande	LG
		Mene Grande-Creole	LM
Merey	Merey	Mene Grande	MG
Nipa	NG-1	Mene Grande	NG

*Prefix added to distinguish between West and East Guara Wells

TOTAL WELLS DRILLED (January 1, 1946)

Yopales	Oficina	Guara	Leona	Merey	Nipa	Miscl	Totals
-	269 OG	76 GG	17 LG	5 MG	1 NG	Tigre 1	369 MGO
19 YS	26 OS	61 GS	-	-	-	-	106 Creole-MGO
-	5 OM	3 GM	8 LM	-	-	Pando 1	17 MGO-Creole
-	-	20 GV	-	-	-	-	20 SVO
19	300	160	25	5	1	2	512

NOTE: All wells drilled and operated by Mene Grande except for the 20 Socony Vacuum wells.

and basement surface. This was finally interpreted as a northeast-southwest-trending anticline and the location was made at its supposed crest. Subsequent drilling development has shown that a structural "high" was present here, but that it was actually the upthrown side of a fault and that the barrier effect of the faulting caused petroleum accumulation.

Oficina No. 1 (OG-1) was spudded in on February 23, 1933. Although somewhat encouraging tests were made from time to time, the drilling and final completion of this well were not actively pushed. In fact, the well was finally completed at the total depth of 6,184 feet on June 16, 1937, producing from 5,292–5,995 feet (L to S sands), at an initial daily rate of 1,327 barrels of 28.5° API oil through a ½-inch choke. (The well was later reworked to a single sand in keeping with subsequently established production practice.)

HISTORY OF EXPLORATION AND DEVELOPMENT

Following the drilling of Oficina No. 1, three other wildcats (Areo No. 1, Oficina No. 2, and Merey No. 1) were drilled by the Mene Grande Oil Company in the Greater Oficina area at locations based largely on refraction-seismograph work. Tigre No. 1, in the extreme eastern part of the area, was drilled during late 1936 and early 1937 but resulted in a dry hole. In 1937, Areo No. 1, Merey No. 1, Oficina No. 1, and Oficina No. 2 were brought in as producers in the order named. Since that time, exploration and exploitation drilling have continued steadily. Table II lists the principal wildcat and long step-out wells which have been drilled to date with some essential information on each well. These various locations are shown in Figure 2. It is noteworthy that of these 45 wells classified as wildcats or exploratory step-outs (more than one mile from production), 30 were producers and 15 were abandoned as dry holes.

Exploitation drilling in the Oficina field began in 1938, and oil from this field was first put through the pipeline to the Puerto la Cruz terminal on the Caribbean coast in August, 1939. The first shipment of oil from this port was made early in December of that year.

Following the discovery of the Oficina field, the more important additional discoveries came as follows.

1937	Areo No. 1, Merey No. 1, Yopales No. 1
1938	Leona (Central)
1939	OS-1 area, L_1 sand, "D" segment
1940	Leona (North)
1941	OG-187 and OG-202 area
1942	West Guara, East Guara
1943	Agua Clara
1944	GS-20, GS-21, GV-1
1945	Moquete, Nipa No. 1

Previous to the drilling of Oficina No 1, the region had been investigated with refraction seismograph and with a few torsion-balance lines, and all of the early wildcat locations were based on these data. Beginning in 1936, and continuing through 1937 and 1938, detailed refraction-seismograph work was done in much

of the area, but it must be admitted that results of this work, as interpreted at the time, show little accordance with structure as known now. A magnetometer survey in 1937 brought out pronounced northeast-southwest trends in the basement, but the magnetic picture has not yet been clearly enough correlated with sedimentary structures to have furnished much help in discovering oil accumulations. Coverage of the whole area with a detailed grid of gravimeter work in 1940 likewise failed to yield results having much practical application to date. Soil analysis and surface electrical prospecting have been tried, but their results can not yet be conclusively evaluated. Surface geological work has given important leads, but at best has been able to furnish only very vague indications of subsurface structure.

Reflection seismograph work and structure drilling were both initiated in 1939 and have been continued with more and more emphasis to the present time. Continued improvements in both these methods as regards technique of operation and interpretation have resulted in their firm establishment as essential prerequisites to exploration drilling in this area. Reflection-seismograph work allows fairly accurate contouring on phantom horizons within individual fault segments by the continuous profile method, and is commonly successful in locating faults which are critically important in oil accumulation. Structure drilling with portable rigs of 1,000–3,000 feet depth capacity, with reliance on electrical logging (rather than cores) for correlation, has provided still more positive means of determining structure, although with the limitation of working at horizons several thousand feet above the producing sands. The combination of closely coordinated reflection-seismograph and structure-drill work constitutes the most effective exploration method developed in this region.

In considering exploration methods, emphasis should also be placed on the contribution of detailed stratigraphic and correlation studies of the deep well sections. The continuously cored sections of the early wells were particularly valuable in this respect. In Table II under the heading of "Final Basis for Location," the type of exploration work which was most directly responsible for each wildcat is given. However, in almost all cases the final choice of locations should also in part be credited to the growing general background of geological information on structural and stratigraphic conditions most favorable for accumulation in this area.

SURFACE FEATURES

Physiography.—The Greater Oficina area occupies a part of the broad grass-covered sandy plains of Eastern Venezuela, commonly known as the "mesa" (Fig. 3). These plains slope gently from west to east from an elevation of about 1,100 feet at the western edge of the area to about 700 feet at its eastern edge. The area is bounded on the north by the valley of Rio Guanipa and in general drains southeastward into the Caris, Tigre, Laysme, and Chive rivers of the Orinoco drainage system.

TABLE II

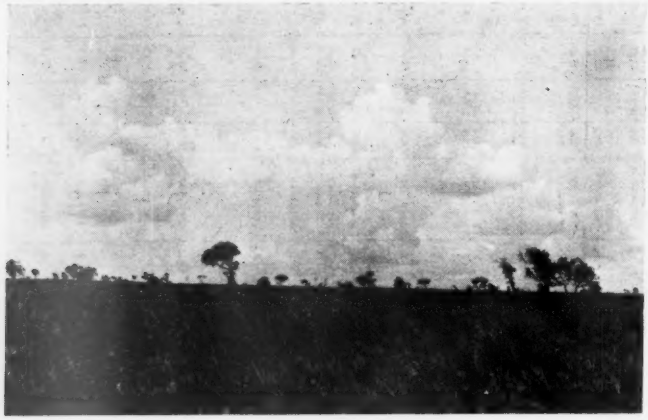
DATA ON WILDCAT AND EXPLORATORY STEPOUT WELLS IN GREATER OFICINA AREA

WELL DESIGNATION	FIELD	DISTRICT	KILOMETERS TO NEAREST PROD	STARTED	COMPLETED	TOTAL DEPTH	NUMBER OF PRODUCTIVE ZONES	NET OAS OR OIL SAND	OVERALL PRODUCTIVE	SECTION	NAME OF PRODUCING SD.	PRODUCING INTERVAL	INITIAL PROD BBLS PER DAY	CHOKE	API GRAVITY	TUBING HEAD PRESSURE	CASING HEAD PRESSURE	GAS OIL RATIO (CU FT PER BBL)	REMARKS	PRODUCTION TO JANUARY 1, 1948	FINAL BASIS FOR LOCATION
OFICINA-1 (OG-1)	OFICINA	OFICINA	1MO. Quiriquire	2-23-33	6-16-37	6184'	11	305'	4049-5995'	L-S	5292-5995'	1327	1/2"	28.5°	1190	-	2500	Reworked to P Sand Interval 5692-5762'	716,083	Refraction Seismo & Torsion Balance
~REO-1	AREO	MERET	28:OG-1	1-7-34	3-17-37	4477'	2	±70'	3705-4079'	F	3900-3925'	435	1"	15.0	-	-	-	No Pipe Line	4,063	Refraction Seismo
OG-2	OFICINA	OFICINA	4:OG-1	2-5-34	9-15-37	6700'	1	14'	5460-5485'	J_m	5455-5490'	3912	7/8"	37.7	355	-	682	-	609,101	Refraction Seismo
MERET-1 (MC-1)	MERET	MERET	16:AREO-1	5-15-34	4-14-37	5856'	3	55'	4615-4780'	J	4650-4665'	618	5/8"	19.0	93	-	-	No Pipe Line	62,937	Refraction Seismo
TIGRE-1	-	PAEDO	38:MO-1	6-14-36	5-22-37	6425'	-	-	-	-	-	-	-	-	-	-	-	Abandoned	-	Refraction Seismo
TOPALES-1 (TS-1)	TS-1	TOPALES	29:OG-1	4-24-37	10-2-37	6015'	1	16'	5740-5760'	N	5739-5756'	1558	5/8"	19.9	230	-	250	No Pipe Line	8,982	Refraction Seismo
TIGRE-2 (LG-1)	LEONA	LEONA	28:MO-1	6-15-37	3-30-38	7815'	1	14'	6350-6365'	I_1	6350-6365'	1392	1/2"	27.6	340	-	610	-	273,969	Refraction Seismo
MERET-2 (MC-2)	-	MERET	8.5:MO-1	10-6-37	2-28-38	6039'	1	10'	4918-4926'	P	4900-4935'	Swabbed 13° oil - fluid level at 1500						-	-	Refraction Seismo
OG-3	OFICINA	OFICINA	6.4:OG-1	11-9-37	5-24-38	6525'	-	-	-	-	-	-	-	-	-	-	-	Abandoned	-	General Stepout
OS-1	OFICINA	OFICINA	2.8:OG-13	3-25-39	6-16-39	6060'	8	175'	4830-6045'	P	5930-6030'	1434	1/2"	30.5	775	-	747	Mainly Gas	48,460	Subsurface
OS-10	OFICINA	OFICINA	3.7:OG-66	4-26-40	8-1-40	6808'	-	-	-	-	-	-	-	-	-	-	-	Abandoned	-	Surface Geology & Refraction Seismo
OS-11	OFICINA	OFICINA	2.8:OG-36	5-15-40	7-19-40	6510'	1	40'	5619-5661'	R_4	5630-5685'	410	3/8"	17.6	340	-	230	-	275,625	Reflection Seismo
LM-1	N. LEONA	LEONA	6.4:LG-1	7-18-40	11-12-40	8310'	3	25'	7605-7657'	I_{2-3}	7630-7657'	1350	7/16"	26.1	740	-	630	-	278,748	Surface Geology
OG-85	-	OFICINA	2.8:OG-37	7-25-40	9-9-40	6514'	-	-	-	-	-	-	-	-	-	-	-	Abandoned	-	Reflection Seismo
OG-91	-	OFICINA	1.6:OG-4	8-5-40	10-15-40	5900'	-	-	-	-	-	-	-	-	-	-	-	Abandoned	-	Reflection Seismo
OG-110	OFICINA	OFICINA	3.1:OG-74	10-8-40	12-20-40	5850'	2	17'	4820-5015'	J_{2}	4835-4850'	392	7/16"	22.8	200	-	-	-	5,601	Structure Drill & Reflection Seismo
OS-13 (OS-13)	OS-13	GUARA	9.2:OG-37	11-19-40	1-30-41	7005'	1	16'	5302-5339'	F_{5-6}	5334-5330'	404	7/16"	21.0	125	-	-	-	11,024	Structure Drill & Reflection Seismo
OG-168	OG-167	OFICINA	3.7:OG-116	4-1-41	5-23-41	6000'	3	55'	5005-5870'	H_L	5384-5392'	228	5/16"	32.6	200	-	-	-	8,212	Reflection Seismo & Structure Drill
OG-176 (OG-176)	-	GUARA	2.3:OS-13	5-12-41	9-7-41	6225'	-	-	-	-	-	-	-	-	-	-	-	Abandoned	-	Reflection Seismo
OG-191	-	OFICINA	2.6:OG-181	7-10-41	8-5-41	6125'	-	-	-	-	-	-	-	-	-	-	-	Abandoned	-	Reflection Seismo & Structure Drill
LG-3	N. LEONA	LEONA	1.7:LM-2	8-17-41	10-17-41	7750'	2	17'	7494-7543'	I_6	7494-7510'	448	1/2"	34.0	1000	-	-	-	1,000	Reflection Seismo & Structure Drill

OG-191	-	OFICINA	2.6:OG-181	7-10-41	8-5-41	6125'	-	-	-	-	-	-	-	-	-	-	-	Abandoned	-	Reflection Seismo & Structure Drill

LG-5	N. LEONA	LEONA	1.7:LE-2	8-17-41	10-17-41	7750'	2	17'	7494-7543'	I_2	7494-7510'	642	5/16"	30.0	720	860	520	-	134,827	Subsurface Geology & Reflection Seismo
OG-202	OG-202	OFICINA	4.2:OG-37	9-6-41	11-9-41	6450'	4	82'	4890-6154'	F_5 H_1	4970-4975' 6137-6142'	500 480	5/16" 5/16"	34.7 19.0	- 440	400 -	620 450	- -	660,817	Structure Drill & Reflection Seism
OG-204	-	OFICINA	3.3:OG-13	9-9-41	9-30-41	6150'	-	-	-	-	-	-	-	-	-	-	-	Abandoned	-	Reflection Seismo
LM-6	-	LEONA	4.4:LG-6	10-18-41	12-28-41	7443'	-	-	-	-	-	-	-	-	-	-	-	Abandoned	-	Reflection Seismo
GS-1	-	GUARA	3.7:OG-13	1-23-42	3-11-42	7307'	-	-	-	-	-	-	-	-	-	-	-	Abandoned	-	Reflection Seismo
GG-1	W. GUARA	GUARA	8.7:OG-18	3-4-42	6-2-42	8096'	6	128'	6150-7000'	I_2 M_u	6248-6268' 6724-6734'	556 705	5/16" 5/16"	37.6 21.8	- 460	550 -	370 300	- -	456,383	Reflection Seismo
LG-13	N. LEONA	LEONA	1.6:LG-5	2-8-42	5-5-42	8047'	5	63'	7185-7480'	G J_L	7180-7130' 7445-7475'	407 325	1/4" 1/4"	28.5 30.3	- 470	550 -	460 400	- -	224,576	Subsurface & Reflection Seismo
GG-2	E. GUARA	GUARA	13.5:LG-9	3-19-42	9-7-42	7869'	9	259'	4765-7600'	J_L	6840-6850'	500	5/16"	29.5	500	-	600	Reworked to F_{6-7} and Oficina-1	330,012	Reflection Seismo
GM-1	-	GUARA	8.3:OG-1	4-3-42	6-2-42	7755'	-	-	-	-	-	-	-	-	-	-	-	Abandoned	-	Reflection Seismo
GG-4	-	GUARA	4.5:OG-13	6-6-42	7-15-42	7400'	-	-	-	-	-	-	-	-	-	-	-	Abandoned	-	Reflection Seismo & Structure Drill
GM-2	AVENTAZON	OFICINA	10.3:OG-11	8-21-42	10-27-42	5421'	3	53'	3135-4010'	F J	3650-3660' 3960-4010'	Gas 237	5/16" 1/2"	- 16.4	- 210	1140 -	- -	F Gas Lift J	28,191	Structure Drill
GS-4	-	GUARA	3.3:LG-17	4-24-43	7-10-43	8330'	-	-	-	-	-	-	-	-	-	-	-	Abandoned	-	Structure Drill & Reflection Seismo
YS-2	AGUA CLARA	YOPALES	6.4:YS-1	7-17-43	9-15-43	5592'	1	410'	3999-4012'	J_L	3999-4004'	234	1/4"	25.6	200	-	430	-	18,991	Structure Drill
GM-3	AVENTAZON	OFICINA	4.5:OG-11	9-2-43	10-15-43	5491'	2	72'	3890-4460'	F_6 J_L	3900-3910' 4430-4440'	522 330	5/16" 5/16"	21.5 21.5	- 220	720 -	860 160	- -	49,366	Structure Drill
GV-1	W. GUARA	GUARA	1.9:WOG-14	4-1-44	6-20-44	7067'	17	341'	5000-6950'	D_u H	5410-5435' 6304-6253'	680 609	5/16" 5/16"	40.5 38.6	- 775	605 -	645 980	Saccony-Vacuum Well	584,351	Reflection Seismo
YS-11	YS-11	YOPALES	5.9:OG-187	4-9-44	5-23-44	5600'	1	5'	4344-4349'	L_5	4344-4349'	-	-	31.0	-	-	-	Headed Wet Oil	-	Structure Drill
GG-24	E. GUARA	GUARA	3:EOG-16	5-3-44	7-19-44	7787'	1	19'	6640-6667'	J_L	6650-6660'	-	-	23.0	-	-	-	Potential Pumper	-	Structure Drill & Reflection Seismo
PANDO-1	-	PANDO	18.5:LM-5	7-11-44	9-4-44	6900'	-	-	-	-	-	-	-	-	-	-	-	Abandoned	-	Structure Drill
GS-20	E. GUARA	GUARA	2.7:OG-24	7-22-44	11-18-44	7201'	7	225'	4440-6120'	Of-11 F_{6-7}	5063-5095' 5950-5965'	644 164	5/16" 5/16"	36.8 29.8	- 70	640 -	685 300	- -	175,610	Structure Drill & Reflection Seismo
GS-21	GS-21	GUARA	3.3:EOG-16	7-28-44	10-5-44	8805'	5	53'	6195-6420'	S_u	6500-6522'	495	3/8"	16.5	195	-	-	No Pipe Line	-	Structure Drill & Reflection Seismo
YS-14	YS-14	YOPALES	5.5:YS-1	10-10-44	12-4-44	4973'	19	536'	2950-4500'	T	4391-4390'	380	3/8"	16.8	95	-	230	No Pipe Line	-	Structure Drill
YS-15	MOQUETE	YOPALES	7.5:YS-14	12-10-44	1-28-45	5800'	6	175'	3340-4510'	F	4180-4190'	433	5/16"	23.9	260	-	400	No Pipe Line	-	Structure Drill
GM-2	GM-2	GUARA	5.7:OG-13	1-13-45	3-31-45	7200'	1	15'	6350-6390'	J_L	6360-6390'	132	-	17.2	-	-	-	No Pipe Line	-	Structure Drill & Reflection Seismo
YS-16	-	YOPALES	6:YS-15	2-12-45	3-3-45	4700'	-	-	-	-	-	-	-	-	-	-	-	Abandoned	-	Structure Drill
NG-1	NG-1	NIPA	9.2:GV-2	8-10-45	12-18-45	8164'	1	23'	7104-7136'	G	7130-7135'	389	5/16"	37.6	440	-	1035	-	4,192	Reflection Seismo & Structure Drill

The region is physiographically young and drainage is still poorly developed on the mesa surface itself. This surface tends to remain intact due to the presence of resistant iron oxide-cemented capping layers, probably developed by groundwater precipiation. The "mesa" is gently rolling. Relief is slight and is limited largely to gentle swales and divides and here and there flat-topped hills, apparently remnants of previous mesa surfaces. The monotony of the mesa plains, however, is broken abruptly along many of the larger streams and their tributaries where these have cut through the mesa cap, forming steep cliffs (*farallones*) up to 100 feet in height and commonly developing badlands topography. The brilliant colors of the dissected Mesa formation deposits give these badland areas striking scenic appearance (Fig. 4).



. FIG. 3.—Typically flat mesa topography.

Climate.—The average daily maximum temperature every month of the year is close to 90°F. and the average daily minimum temperature close to 70°F.

Month	*Average Maximum Temperature*	*Average Minimum Temperature*	*Average Rainfall (Inches)*
January	89.31°F.	68.33°F.	0.544
February	90.04	68.69	0.216
March	92.16	69.68	0.255
April	91.76	71.52	0.885
May	91.64	72.18	4.089
June	88.61	71.48	8.320
July	88.49	70.78	8.404
August	90.23	71.32	8.585
September	91.41	71.74	6.275
October	91.76	71.92	5.047
November	90.84	71.17	2.122
December	89.43	69.66	1.379
			46.121

There is a rainy season extending from May to October, the average annual rainfall being just over 46 inches. Trade winds blow from the northeast almost without cessation during the dry season, and because of these winds the heat of the day is ordinarily not disagreeable and the evenings seem fresh and cool. The air is dry.

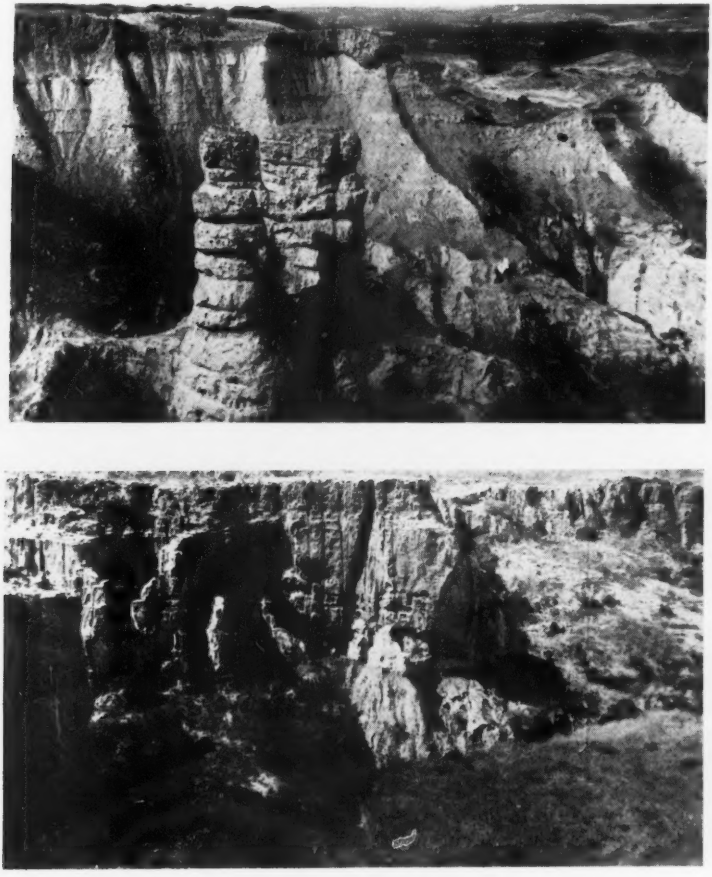


FIG. 4.—Typical farallon development.

A summary of monthly temperatures and rainfall based on ten years of daily observations recorded by the geological department of the Mene Grande Oil Company shows that the maximum temperature recorded for any day during this 10-year interval was 98°F.; the minimum temperature recorded was 62°F.

FIG. 5.—San Tomé. Southward view from water tower.

1–8: A-C —North camp residential
2: A —Hospital
3: D —Tennis courts
3: E —Tee No. 1 (9-hole golf course)
4: A —Mess hall
5: A —Laundry
6: A —Commissary
6: D —Club house
7–8: A —Warehouses
8: B —Office building
8–9: A —Machine and welding shops
9: C —Ball diamond
10–11: A —Parts warehouse and garage
6–10: Beyond A —South camp residential

Geography.—The Greater Oficina area appears to have been fairly well settled in the preceding century, but in common with much of Eastern Venezuela declined in population so that at the beginning of the period of oil-field activity it was very sparsely inhabited and possessed no towns other than a few groups of scattered houses (*vecindarios*) along the principal rivers. The inhabitants subsisted through small-scale cattle raising and farming, but the generally unfavorable nature of the very sandy soil, its low phosphorus and nitrogen content, and the poorly nutritious character of the mesa grass, all tended to discourage any increase of population.

FIG. 6.—Typical mesa vegetation

A savanna road and telegraph line passing through the area from Ciudad Bolivar on the Orinoco River to Barcelona on the Caribbean coast furnished the principal means of exterior contact. A relay station along this telegraph line near the site of the present town of El Tigrito was known as the "Oficina de Telegrafo" or simply as "Oficina." Although this station was 13 kilometers from the location of the discovery well, it gave its name to that well—Oficina No. 1.

With the development of the Oficina field, the mushroom town of El Tigre sprang up on the previously deserted prairie in the midst of this field and in a few years had attained a population of 10,000–15,000 inhabitants. Tigrito, farther east and near the site of the old telegraph station, has similarly grown to a population of several thousand with development of the Guara district fields. Large oil-field camps have been built by the Mene Grande Oil Company at Oficina and at San Tomé (Fig. 5) and there are smaller camps at Leona and the Oficina tank farm, at Guico (Socony) and North Oficina (Schlumberger and Halliburton). There is an excellent air field at San Tomé and this camp has radio and radio-

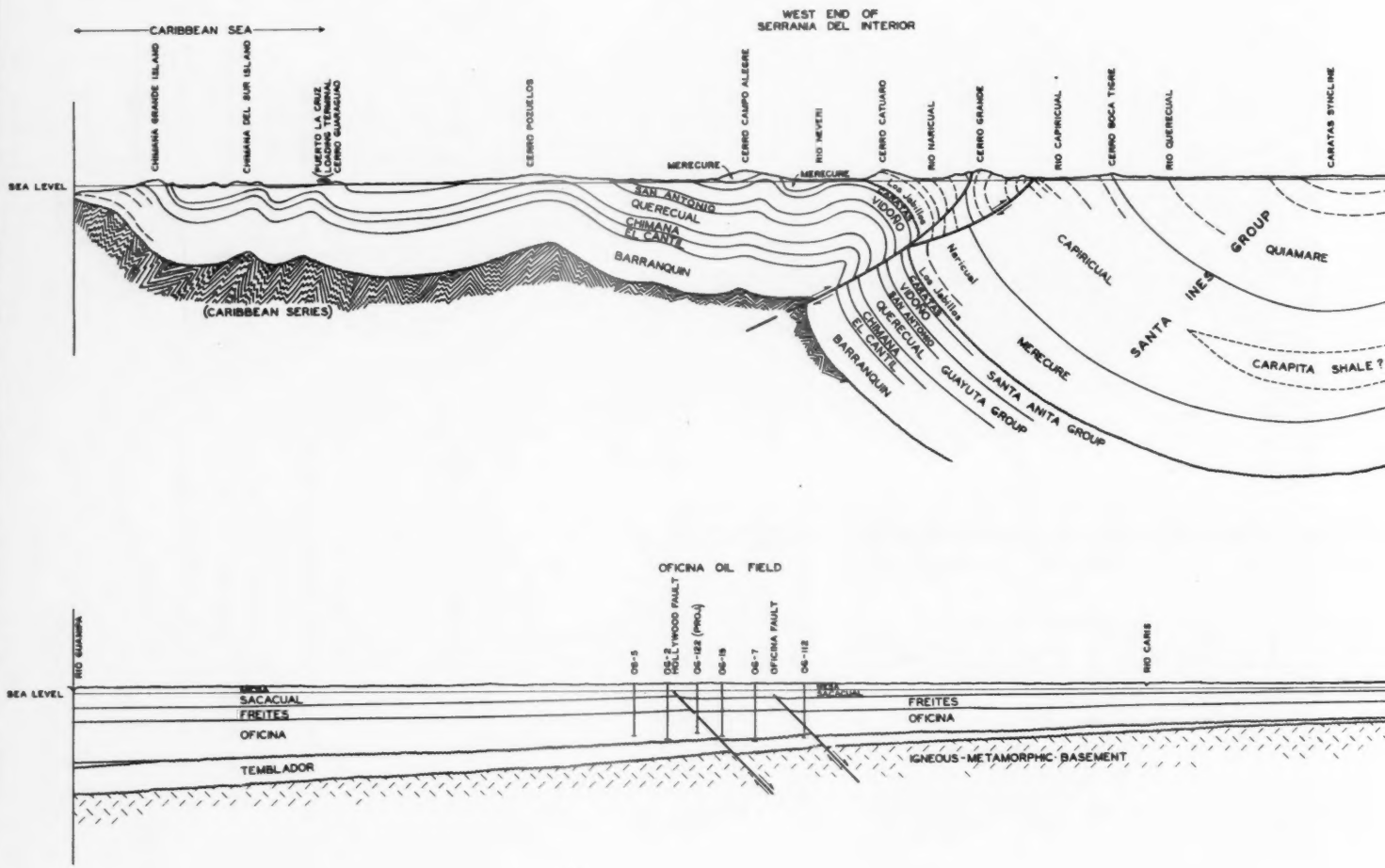
telephone connection with the rest of the country and with the United States. The savanna road to Ciudad Bolivar is used the year around and another savanna road to Pariaguan furnishes road connection with Caracas. However, the principal oil-field traffic is over the improved highway built by the Mene Grande Oil Company to Puerto la Cruz on the Caribbean coast.

Areal geology and vegetation.—The most of the Greater Oficina area is covered by a nearly horizontal blanket of Quaternary Mesa formation. The outcrop area of this formation typically supports only a limited flora characterized principally by coarse grasses and scattered *chaparro* and *alcornoque* trees (Fig. 6). Along the

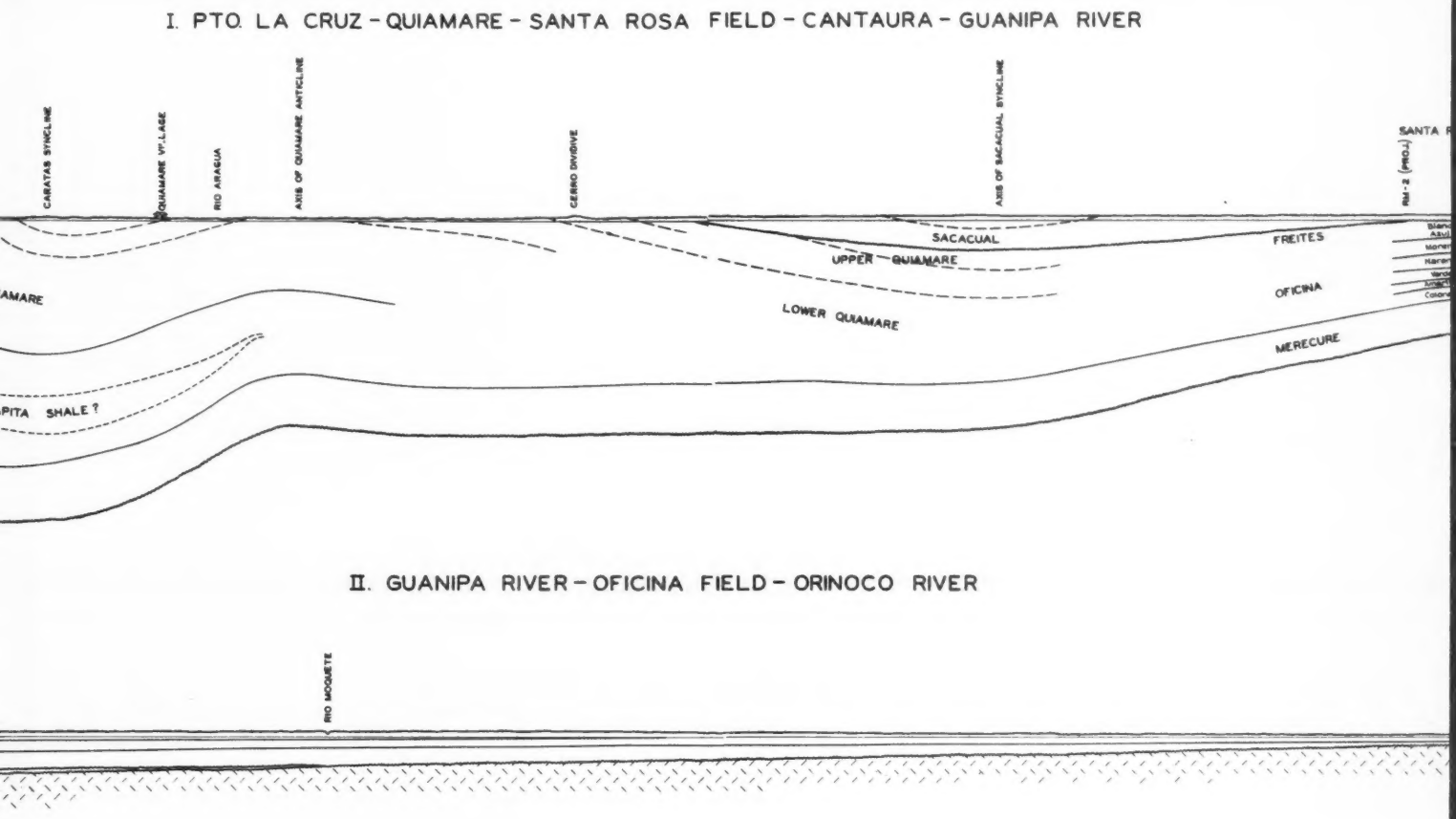
FIG. 7.—Typical dense vegetation along rivers.

larger stream courses enough Recent alluvium has accumulated above the Mesa formation to allow the development of a more varied vegetation of which the *moriche* palm is particularly characteristic (Fig. 7). The local presence of clay strata in the Mesa formation near the surface results in occasional patches of woods or dense brush.

At the headwaters of the Caris, Guico, Cachama, and Laysme rivers and in many of the tributaries of the Laysme and Chive rivers in the eastern part of the area, erosion has cut through the Mesa formation to expose members of the Pliocene Sacacual group. However, nowhere in the area are rocks older than Sacacual known at the surface. The borders of Sacacual outcrop areas are likely to be marked by steep cliffs or badlands topography due to the breaking down of the resistant mesa cap, but the broader outcrop areas of these beds form a gently hilly topography. Sacacual outcrop areas support a heavier vegetation than the Mesa formation and are characterized by *roble* trees, finer grasses, and *cardon* cactus.


CARIBBEAN SEA
WEST END OF SERRANIA DEL INTERIOR
CHIMANA GRANDE ISLAND
CHIMANA DEL SUR ISLAND
PUERTO LA CRUZ
CERRO GUARAGUAO
CERRO POZUELOS
MERECURE
CERRO CAMPO ALEGRE
RIO NEVERI
CERRO CATUARO
RIO NARICUAL
CERRO GRANDE
RIO CAPIRICUAL
CERRO BOCA TIGRE
RIO QUERECUAL
CARATAS SYNCLINE
SEA LEVEL
SAN ANTONIO
QUERECUAL
CHIMANA
EL CANTIL
BARRANQUIN
(CARIBBEAN SERIES)
Los Jabillos
VIDONO
Naricual
CAPIRICUAL
GROUP
QUIAMARE
SANTA INES
CARAPITA SHALE ?
MERECURE
SANTA ANITA GROUP
GUAYUTA GROUP
OFICINA OIL FIELD
RIO GUANIPA
OS-5
OS-2 HOLLYWOOD FAULT
OS-122 (PROJ.)
OS-19
OS-7
OFICINA FAULT
OS-112
RIO CARIB
SACACUAL
FREITES
OFICINA
TEMBLADOR
IGNEOUS-METAMORPHIC BASEMENT

FROM CARI

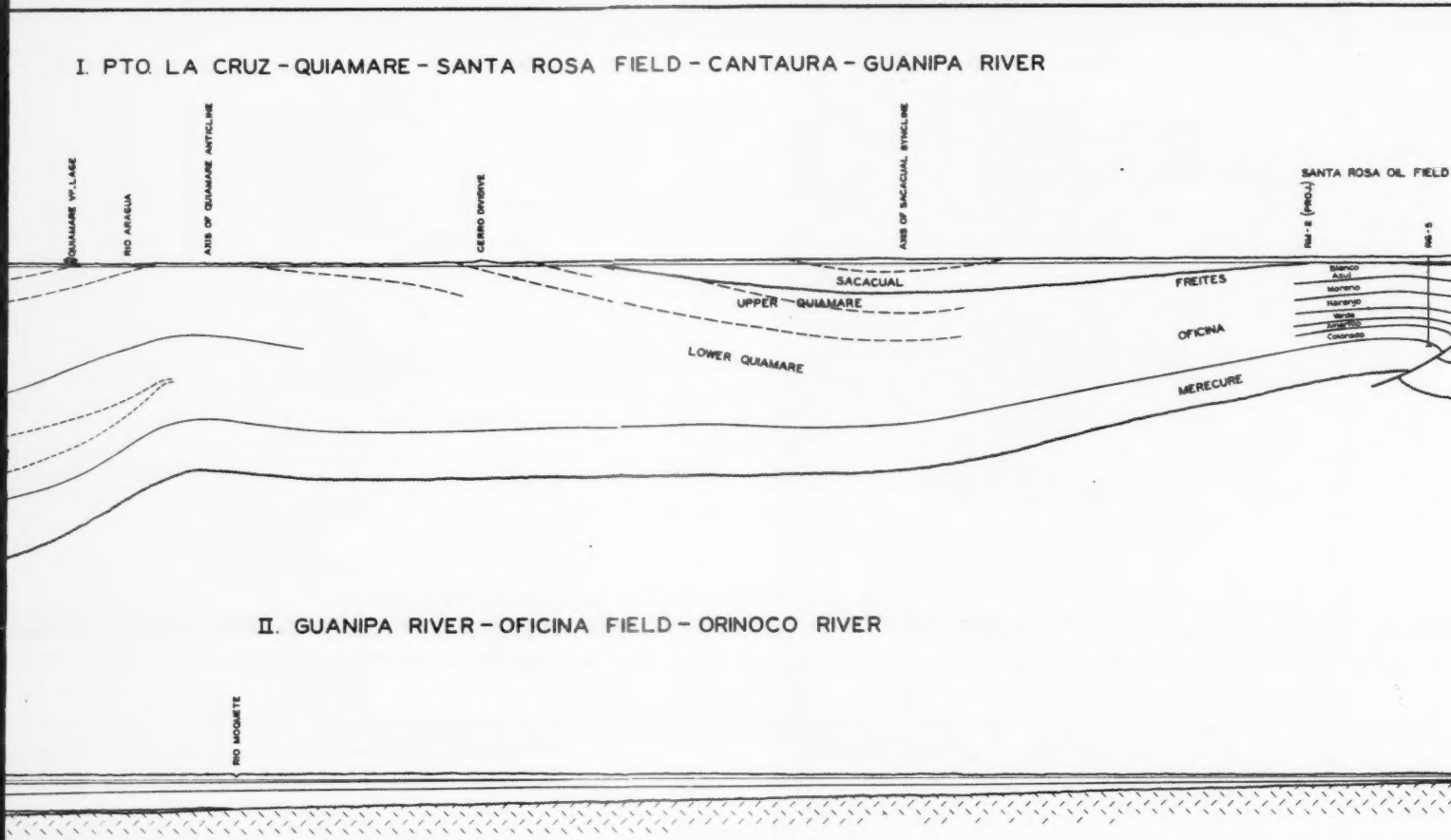


CROSS SECTION - EASTERN VENEZUELA

M CARIBBEAN SEA SOUTH 15° EAST THROUGH PTO. LA CRUZ LOADING TERMINAL, SANTA ROSA FIELD AND OFICINA FIELD TO ORINOCO RIVER

HORIZONTAL AND VERTICAL SCALE

FIG. 8.—Cross section of Eastern Venezuela showing position of Oficina field with respect to structural basin and geosyncline.



CROSS SECTION - EASTERN VENEZUELA

BBEAN SEA SOUTH 15° EAST THROUGH PTO. LA CRUZ LOADING TERMINAL, SANTA ROSA FIELD AND OFICINA FIELD TO ORINOCO RIVER

HORIZONTAL AND VERTICAL SCALE

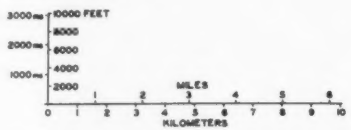
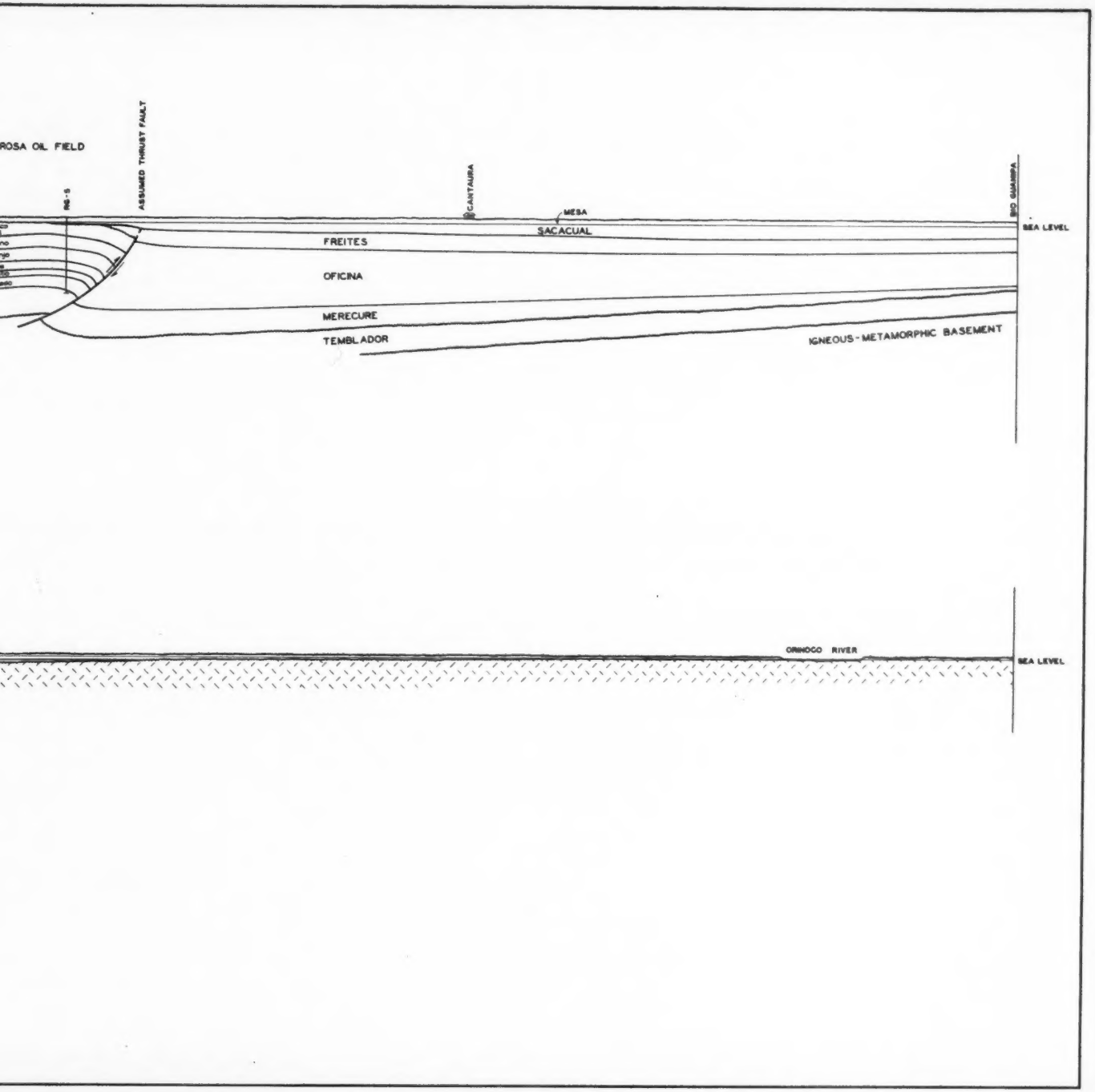
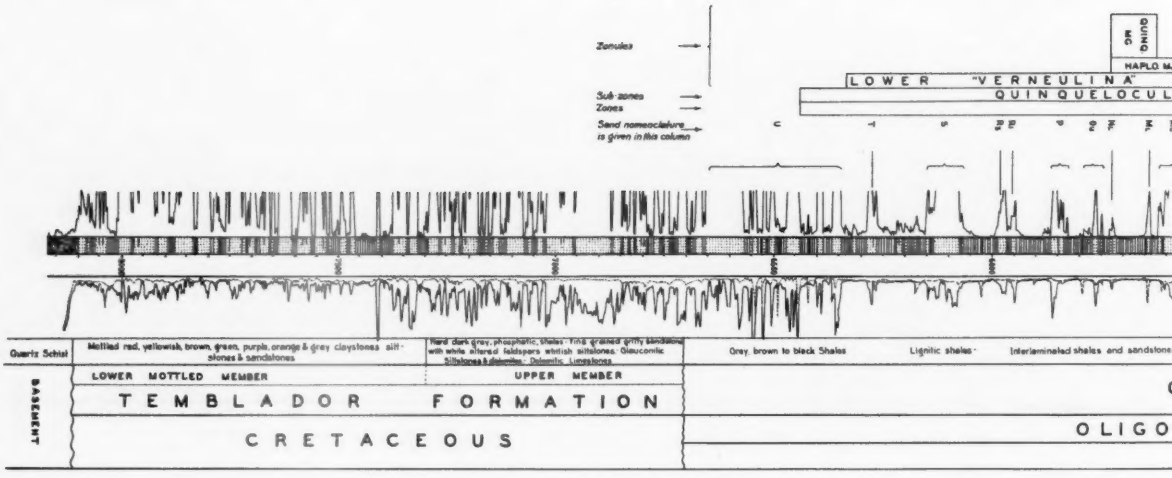


FIG. 8.—Cross section of Eastern Venezuela showing position of Oficina field with respect to structural basin and geosyncline.


ROSA OIL FIELD
RG-9
ASSUMED THRUST FAULT
CANTAURA
MESA
SACACUAL
RIO GUANIPA
SEA LEVEL
FREITES
OFICINA
MERECURE
TEMBLADOR
IGNEOUS-METAMORPHIC BASEMENT
ORINOCO RIVER
SEA LEVEL


Zonules
Sub-zones
Zones
Send nomenclature is given in this column
LOWER "VERNEULINA"
QUINQUELOCUL
Quartz Schist
Mottled red, yellowish, brown, green, purple, orange & grey claystones silt-stones & sandstones
Hard dark grey, phosphatic shales- Fine grained gritty sandstone with white altered feldspars whitish siltstones. Glauconitic Siltstones & dolomites- Dolomitic Limestones
Grey, brown to black Shales
Lignitic shales-
Interlaminated shales and sandstone
BASEMENT
LOWER MOTTLED MEMBER
UPPER MEMBER
TEMBLADOR FORMATION
CRETACEOUS
OLIGO

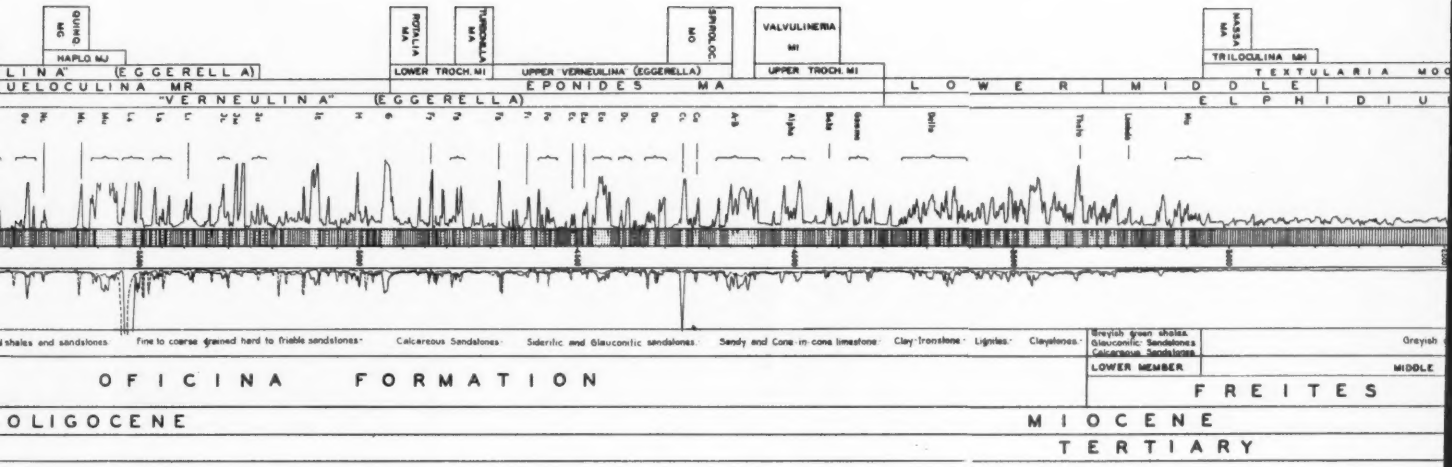


FIG. 9.—Typical columnar section.

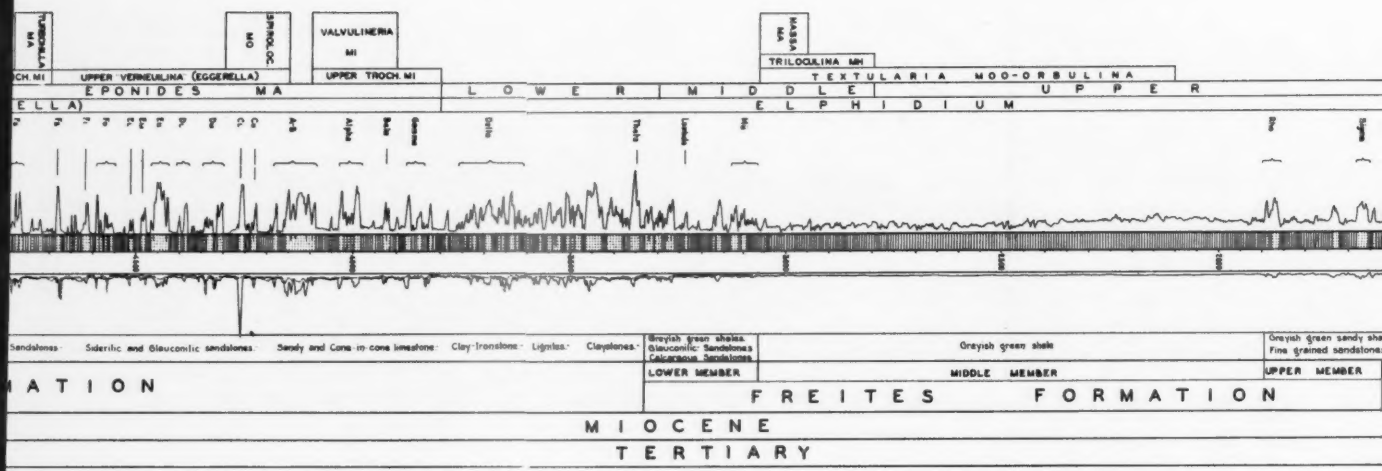
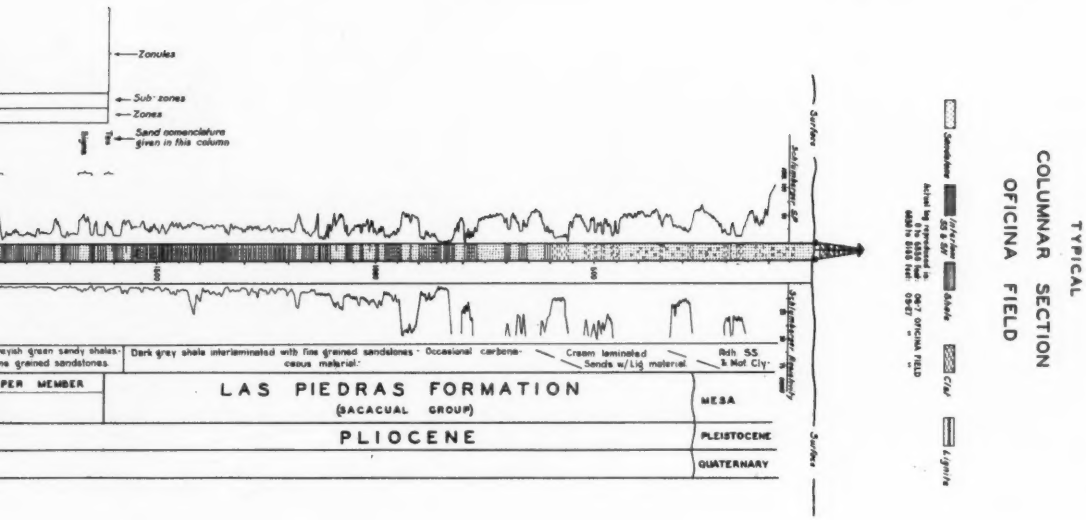


FIG. 9.—Typical columnar section.



TYPICAL
COLUMNAR SECTION
OFICINA FIELD

Surface indications of oil or gas.—No seepages of oil or gas of sufficient magnitude to be detected by ordinary methods of observation are known anywhere in the Greater Oficina area.

STRATIGRAPHY

REGIONAL

The section penetrated by wells in the Greater Oficina area is composed of sediments deposited on the southern limb of the Eastern Venezuela geosyncline near the edge of the Guayana shield. Initial deposits resting on the basement rock of the shield are Cretaceous in age (Temblador formation). Unconformably overlying the Cretaceous sediments is a series of marine and alternating marine and brackish-water deposits of Oligocene and Miocene age constituting the Oficina and Freites formations. These beds are equivalent to the upper part of the Santa Ines formation known from outcrops along the mountain front 100 kilometers farther north. They form the greater part of the thickness drilled by the wells and the Oficina formation contains all of the productive sands known to date. The Freites formation grades upward into brackish-water sediments of the upper Miocene-Pliocene Sacacual group (Las Piedras and Algarrobo formations), which are in turn unconformably overlain by the Quaternary Mesa formation. Regional relations of these formations or their time equivalents have been discussed previously with regard to the history of the Eastern Venezuelan geosyncline.[5] Figure 8 shows a cross section of the Eastern Venezuelan basin to normal scale from Puerto la Cruz on the Caribbean Sea extending S. 15° E. through the Oficina field to the Orinoco River. This section brings out the position of the Oficina field with respect to the present structural basin of Eastern Venezuela, as well as to the Eastern Venezuelan geosyncline.

The character of individual formations as known in the fields of the Greater Oficina area is here briefly summarized in order of descending stratigraphic position (order of penetration by the drill). Figure 9 is a typical columnar section of Oficina field.

MESA FORMATION

The formation is named from the large, comparatively high, flat, topographic feature known throughout Eastern Venezuela as the "mesa," which is largely composed of rocks of this formation. No specific type section has been designated, but innumerable fairly complete reference sections are exposed along the mesa front.

As seen in outcrop, the formation consists largely of massive pink, buff, or red friable sandstones with some quartz-pebble conglomerates. Beds are very lenticular and ordinarily cross-bedded. Lenses of red and gray mottled claystones and

[5] H. D. Hedberg and A. Pyre, "Stratigraphy of Northeastern Anzoategui, Venezuela," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 28, No. 1 (January, 1944), pp. 1–28; 4 figs. incl. geological map.

sandy claystones are common. The mesa "cap" is commonly a massive dark red ferruginous pebbly and sandy rock, which may in large part be of residual origin and indurated by ground-water cementation. This rock is generally associated with red and gray mottled poorly sorted sandy claystone and clayey sandstone. Ferruginous concretions are commonly left as a residual deposit on the mesa surface.

The Mesa formation rests on sediments of the Sacacual group. In some areas an erosional and even angular relation is evident, but in other places the contact appears to be transitional. It has rarely been determined in well sections. The thickness of the Mesa formation commonly ranges from almost nothing to about 250 feet, but may be as great as 400 feet due to local channelling into Sacacual sediments.

Mineralogically the formation is characterized by a heavy-mineral suite consisting of zircon, tourmaline, ilmenite, and rutile, plus staurolite, kyanite, andalusite, sillimanite, and abundant magnetite. Fossils are limited to petrified wood and other plant remains. The formation is considered to be Quaternary (Pleistocene) in age, inasmuch as it is younger than the supposedly Pliocene Sacacual group and older than the Recent stream deposits. Mesa sediments are definitely non-marine and appear to be a combination of fluvial, lacustrine, residual, and possible eolian deposits.

The formation is soft and easily drilled. Circulation is sometimes lost in the porous mesa sands, especially near *farallon* edges. Electrical logs indicate the formation to consist largely of very permeable sand with high resistivities due to fresh water. Correlation of electrical logs is ordinarily impossible in the Mesa formation because of rapid lateral variation in the beds.

SACACUAL GROUP

This group is named from Quebrada Sacacual, a tributary of Rio Unare in the north-central part of the state of Anzoategui. It has been applied as a general name to the brackish- to fresh-water upper Miocene and Pliocene sediments of Eastern Venezuela, lying below the Mesa formation and above the uppermost definitely marine Miocene beds. Local facies differences have been the basis for separation into several individual formations. In the Greater Oficina area, the group includes two formations—the comparatively thin Algarrobo formation above, and the much thicker Las Piedras formation below. These are commonly differentiated in outcrop areas, but distinction in well sections is ordinarily impracticable, so that the whole interval is usually referred to as Sacacual group or assigned entirely to the Las Piedras formation.

The upper part of the Sacacual group in the Greater Oficina area (Algarrobo facies) consists of friable medium- to coarse-grained yellowish gray sandstones with laterally variable bodies of light gray claystone or clay-shale. The lower and major part of the group (Las Piedras facies) consists typically of soft interlaminated greenish gray shale and light gray carbonaceous and micaceous sand-

stone, alternating with soft medium- to fine-grained greenish gray micaceous sandstones and intervals of greenish gray clay-shale. Here and there are thin lignites.

The contact of the Sacacual group with the overlying Mesa formation is difficult to place closely, but is drawn approximately at the point of change between the light-colored, poorly bedded and cross-bedded Mesa sediments and the better bedded and more somber-colored Algarrobo facies. In outcrop areas an erosional unconformity can commonly be identified. The contact of the Sacacual group with the underlying Freites formation is gradational. It is placed in general at the top of the uppermost definitely marine bed in the stratigraphic section, thus separating the marine and brackish-water facies of the Freites formation from the brackish- and fresh-water facies of the Sacacual. The first marine fossils are ordinarily encountered at the base of a sandstone interval (known as the Tau sand), which appears as a persistent horizon on electrical logs over much of the Greater Oficina area. The contact is therefore commonly drawn arbitrarily at the base of this sand on the electrical logs.

The Sacacual group thickens markedly eastward and northward throughout the Greater Oficina area from about 400 feet in Yopales No. 1 to more than 2,000 feet in West Guara and more than 3,000 feet in North Leona.

The greatest variety in detrital heavy minerals in the whole stratigraphic section of the Greater Oficina area is attained in sediments of the Sacacual group. The upper part of the group (Algarrobo formation) shows increasing complexity downward, as considerable garnet, chloritoid, epidote, and clinozoisite are added to a moderately simple suite with aluminum silicate metamorphics and magnetite (similar to Mesa formation). The increasing complexity reaches a maximum in the underlying Las Piedras formation, which typically contains all of the aforementioned minerals plus glaucophane and titanite.

The Sacacual group is nearly barren of fossils in this area. A few fish remains, crab claws, and plant remains are found and very rare specimens of *Quinqueloculina fusca* Brady occur. The group was deposited in fresh to brackish water, probably under estuarine or brackish-water gulf conditions. It is probably upper Miocene and Pliocene in age though accurate dating is not yet possible.

The sediments of the Sacacual group are uniformly soft and are easily drilled. On electrical logs, the upper part of the group appears as dominantly fresh-water resistive sand, while the lower part is interlaminated sandstone and shale. The electrical logs bring out the great lenticularity and lateral variability of sediments in this group that make correlation through any distance difficult. However, northeast of the Oficina field basal Las Piedras beds become more persistent.

FREITES FORMATION

The formation takes its name from the district of Freites, state of Anzoategui, and the type section is that penetrated by the wells of the Oficina field in this district. The formation, as a whole, is characterized principally by green to

greenish gray fissile clay-shale. However, it may be divided into three members based on the presence of sandstones near the top and near the base of the formation in contrast to the middle and greater part of the formation which is all shale. The upper member is about 300 feet thick and includes a number of thin, shaly, fine-grained, whitish gray and slightly glauconitic sandstones of remarkable lateral continuity. The lower member is also about 300 feet thick and besides the typical greenish gray shales, includes yellowish green, medium- to coarse-grained, glauconitic, calcareous or sideritic, highly fossiliferous sandstones. Yellowish calcareous clay-ironstone concretions are common in the shales throughout the formation.

The Freites formation grades upward into the Las Piedras formation and downward into the Oficina formation. The upper contact is placed at the top of the highest definitely marine horizon in the section (base of the Tau sand) The Freites-Oficina contact is usually based on the change from the characteristic greenish color of Freites sediments to the gray or brownish gray color of the more carbonaceous Oficina formation This color change is distinct in the western part of the area, but in the northern and eastern parts is not very satisfactory and must be supplemented by other criteria, such as the occurrences of glauconite or of typical Freites fossils.

The Freites formation thickens northeastward throughout the area from 1,100 feet in Yopales No. 1 to 2,000 feet in West Guara, Nipa, and North Leona.

Heavy-mineral assemblages in the Freites formation differ from those of the Las Piedras principally in the general absence of magnetite, andalusite, and sillimanite, and, in the lower member, an even further simplification results in a tendency toward a simple garnet-chloritoid suite.

A great variety of foraminifera and mollusks is known from the Freites formation. The lower member is particularly rich in shallow-water marine fossils. The middle shale member is less abundantly fossiliferous, but appears to have been deposited in a moderately deep-water and dominantly marine environment. The upper member is definitely brackish. The whole formation thus represents a regression from marine to brackish-water conditions. The fossil assemblage of the Freites formation appears to indicate an upper middle to lower upper Miocene age, and correlation with the uppermost part of the Brasso formation of Trinidad and the uppermost part of the Santa Ines formation of northern Anzoategui.

On the electrical logs, the thick middle shale member of the formation is a very distinctive feature in all wells because of the complete absence of any interbedded sands or sandy facies. The sands of the upper and lower members have great lateral persistence, which permits direct electrical-log correlation of wells as much as 40–50 kilometers apart. The intermediate section of solid shale with its very low self-potential effect and resistivity is likewise remarkable from a correlation standpoint because the numerous small oscillations that are recorded through this part of the section have been found to continue in minute detail over

many kilometers. The formation in general is easily drilled with drag-type bits and makes good drilling mud.

OFICINA FORMATION

This formation takes its name from the Oficina field and its type section is in the wells of that field. It consists dominantly of alternations of gray, dark gray, and brownish gray shales, interlaminated and interbedded with light gray fine- to coarse-grained sandstones and siltstones. Thin lignites and lignitic shales, green and light gray claystones with siderite spherules, sideritic glauconitic sandstones, and thin cone-in-cone limestones are important minor constituents. Carbonaceous matter is common and individual well sections in the Oficina field may contain as many as 40 or 50 lignite beds, ordinarily only a few inches in thickness, but in places as much as 2 feet thick. These lignites appear as thin, pronounced, resistive peaks on the reverse curves of electric logs and are of exceptional value in correlation work. Many of the sandstones may be called grits and some are conglomeratic with quartz and chert pebbles. Sandstones in general are thicker, coarser-grained, and more plentiful near the base of the formation.

The Oficina formation is transitional upward into the Freites formation and the contact is drawn rather arbitrarily where the greenish sediments of the Freites give way to the gray or brownish gray, more carbonaceous beds of the Oficina. The Oficina formation rests unconformably on the Cretaceous Temblador formation, with the time value of the unconformity being equal to uppermost Cretaceous, Eocene, and part of Oligocene time. Nevertheless, the contact is everywhere difficult to recognize sharply, due to the fact that adjacent parts of both formations are characterized by thick sand bodies of similar lithologic character. The Oficina formation in this area varies in thickness from about 2,000 feet to about 4,000 feet. The greatest drilled thicknesses are in the north and there is a continued northward thickening beyond the limits of the Greater Oficina area.

A garnet-chloritoid mineral suite with some staurolite characterizes the formation in the western part of the area. However, chloritoid weakens with depth and weakens eastward, and in the eastern part of the area this suite is replaced by a garnet-staurolite suite with abundant ilmenite. The formation contains a fairly rich fauna, including more than 100 species of foraminifera and more than 200 molluscan species. An Oligocene-Miocene age is definitely established and the formation may be correlated with parts of the Santa Ines group of northern Anzoategui and parts of the Brasso formation of Trinidad. Combined faunal and lithologic evidence indicates that deposition of the formation started under fresh- or brackish-water conditions and continued through repeated alternations of shallow-water marine, brackish-water, and coal-swamp environments. Conditions in general become more marine from west to east and from south to north.

Electrical logs bring out the alternation of sands and shales throughout the formation and also clearly indicate lignites and limestones. Correlation based on

electrical logs is very good. The formation is readily drilled, but below depths of 3,500–4,000 feet it is sufficiently compacted to warrant the continuous use of roller-type bits.

TEMBLADOR FORMATION

The Temblador formation was named from the Temblador oil field in the southeastern part of the state of Monagas where it was first penetrated by drilling. However, the completely cored section of the Tigre well No. 1 (interval 5,805–6,421 feet) in the southeastern part of the Greater Oficina area first established the age and stratigraphic relations of the formation and may be considered as the standard reference section. Other good completely cored reference sections are those of Yopales No. 1 and Merey No. 2. The formation is not known in outcrop. It has been divided into two members: an upper glauconitic member, and a lower mottled member.

In the Tigre No. 1 reference section, the upper member is 312 feet thick (interval, 5,805–6,117 feet). It consists largely of gray, greenish gray and green glauconitic fine-grained sandstones and siltstones, gray friable coarse and gritty sandstones, dark carbonaceous phosphatic shales, whitish powdery sandstones and siltstones, and thin beds of hard gray massive glauconitic and commonly fossiliferous dolomites and dolomitic limestones. The member thickens westward and northward (about 600 feet thick in southern part of Oficina field) but is fairly constant in lithologic character. In addition to the features shown by the Tigre No. 1 section, other well sections bring out the predominance of sandstones, the presence of occasional intervals of mottled claystone and whitish claystones with large siderite spherules and thin sandstones cemented by pyrite.

The lower mottled member in the Tigre No. 1 reference section is 304 feet thick (interval, 6,117–6,421 feet). This member is made up of coarse grits, sandstones, siltstones, and claystones, all ordinarily mottled in dull shades of light gray, greenish gray, yellow, brown, red, and purple. Whitish powdery grits, sandstones, and siltstones are common in this member, as well as in the upper member, and there are some intervals of bluish gray claystone with plant remains. The lower member also thickens westward (800 feet thick in southern part of Oficina field). The division between the two members is drawn principally on the absence of glauconite and predominance of mottled beds in the lower member.

The total thickness of the Temblador formation is 616 feet in Tigre No. 1, 592 feet in Merey No. 2, 1,299 feet in Yopales No. 1, and 1,470 feet in OS-27 in the southern part of the Oficina field. Just west of the Greater Oficina area exploratory wells have encountered more than 2,000 feet of the formation.

In consideration of the time gap between the Cretaceous Temblador formation and the Oligocene-Miocene Oficina formation, the contact between the two is probably at least disconformable, yet surprisingly there is no discernible angular relation in the well cores, and careful laboratory work on a continuously cored section is required to determine the contact accurately. Both formations are

dominantly sandy near the contact and the Temblador is, if anything, less indurated than the Oficina. There is little lithologic difference between most of the adjacent sediments of the two formations, and the distinction must be made ordinarily on mineral or fossil evidence or on special lithologic characters of the Temblador formation, such as the phosphate content, the presence of white powdery sands (decomposed feldspar), and dolomitic limestones. On the south, the formation is completely overlapped by the Oficina formation.

The Temblador formation of the Greater Oficina area rests with profound unconformity on the igneous and metamorphic rocks of the Guayana basement complex. The base of the formation is thus accurately determinable, except as obscured by the local presence of a thin weathered zone of basement rock grading up into the sediments. West of the Greater Oficina area, the Temblador formation rests unconformably on the Carrizal formation, probably early Mesozoic in age.

The detrital mineral suite of the Temblador formation in the Greater Oficina area is relatively simple except for sporadic occurrences of fairly abundant garnet and staurolite. The lower member is particularly characterized by common monazite and grains of pleonaste. Ilmenite is usually greatly in excess of leucoxene. Anatase and brookite are more common than in the overlying Oficina formation. The almost complete absence of chloritoid in the Temblador formation is a useful means of distinction from the overlying sands of the Oficina formation. Feldspar is generally a common constituent though ordinarily decomposed to give the whitish powder characteristic of many Temblador sandstones and siltstones.

The discovery in the upper member of the Temblador formation of Tigre No. 1 of thin dolomitic limestones containing species of *Exogyra*, *Plicatula*, *Astarte*, *Neithea*, and *Turritella* definitely established the Cretaceous age of the formation. Subsequently, a poorly preserved ammonite and questionable specimens of *Requienia* were recovered in OS-27. Fossils are not very common in the formation and with the exception of plant remains are completely unknown from the lower member. Dark shales in the upper member have commonly yielded a species of linguloid brachiopod, fish remains, and a few arenaceous Foraminifera. Plant remains are also known from the upper member. The fossil evidence is insufficient to fix definitely the position of the formation within the Cretaceous. Fossils from the Tigre No. 1 dolomitic limestones were submitted to R. W. Imlay of the United States National Museum, who is inclined to believe that they are not older than Cenomanian.

The lower Temblador is evidently a non-marine deposit derived directly from erosion of the Guayana shield igneous and metamorphic complex. The upper Temblador deposits, on the other hand, represent an alternation of brackish lagunal and swamp conditions with a true shallow-water marine environment. It is difficult to say what part of the outcropping Cretaceous section of the Caribbean Cordillera on the north is the time equivalent of the Temblador. Although lithologically perhaps most similar to the Lower Cretaceous Barranquin forma-

tion, it is entirely possible that the Temblador may be the near-shore and continental facies of much of the marine Upper Cretaceous farther north.

Except for the hard dolomitic layers, the Temblador formation is less indurated and more easily drilled than the overlying Oficina formation. Electrical logs bring out the marked predominance of permeable strata (sandstones) over clays and shales throughout the whole formation. Self-potential effects in these sands are high and resistivities obtained with shallow penetration devices are also generally high due to the deep penetration of fresh water from the drilling mud into these very permeable sands.

Electrical logs are of little value in correlation, apparently because of rapid lateral variations within the formation. However, since no oil has been produced from the Temblador, very few wells (none closely spaced) have been drilled into the formation. Closer spacing would undoubtedly improve the electrical-log correlation in at least the marine parts of the upper member.

BASEMENT

Wells in the Greater Oficina area have encountered igneous-metamorphic basement rock as follows.

Well	*Basement Depth (Feet)*	*Total Well Depth (Feet)*	*Character of Basement*
Tigre No. 1	6,421	6,425	Slightly gneissic granite
Merey No. 2	6,036	6,039	Slightly gneissic quartz-diorite
Yopales No. 1	5,999	6,015	Granitoid gneiss with bands of greenstone
OS-27	7,250	7,308	Biotite-oligoclase quartz schist or phyllite

The variety of rock encountered by the four wells which have reached basement in this area indicates its probable complexity. This is also borne out by wells farther east and south which show an even greater variety of basement rock types.

There is no question that the igneous-metamorphic rock represents a very old weathered and eroded surface on which the Cretaceous Temblador formation was deposited. Basement was readily identified by drilling character in all wells, excepting OS-27, where it was penetrated 58 feet before the well was stopped. The basement rock appears clearly on the electrical log with low self-potential effect and high resistivity.

CORRELATION

The continuous coring in all the early wildcats and step-outs in the Greater Oficina area made possible fairly accurate inter-well correlation from the very beginning. In the non-marine upper part of the section, heavy-mineral data were used to supplement lithologic correlation, and in the Freites and Oficina formations, paleontologic zones and marker horizons which could be carried throughout most of the area were established.

With the beginning of exploitation drilling and the need for more detailed correlation, a system of correlation horizons (numbered from 1 to 190) was de-

termined by careful lithologic and paleontologic study of the cored sections and these horizons provided accurate ties throughout the area. Similarly, sands and sand groups throughout the known producing section were correlated and were given letters from A to U in order of descending stratigraphic position. Subdivisions of these sands or sand groups were designated by sub-numbers or by the terms upper, middle, and lower. Both the numbered correlation horizons and the lettered sands are in use at present. Figure 9 is a typical columnar section in the Oficina field.

Electrical surveys have been made in all wells from the beginning with the exception of Areo No. 1. In the early stages of exploration drilling, these were of little value in correlation due to the long distances between wells, the use of manual recording, and the fact that the shortening effects of faulting had not yet been recognized. However, soon after the commencement of exploitation drilling in the Oficina field, the electrical logs began to be indispensable in correlation and they have now superseded all other methods excepting in the case of long step-outs or wildcats where paleontological markers still serve an important purpose.

The continuity of strata in the Freites and Oficina formations is such that the system of sand nomenclature developed in the Oficina field has now been extended by means of electrical logs and fossil correlation horizons throughout the Greater Oficina area. The need for a nomenclature for sand bodies in the Freites formation and in the upper part of the Oficina formation above the A sand was met by applying the Greek alphabet in order upward from the A sand. Later when the upper Oficina sands of the East Guara field were discovered to be productive, the Greek letters for this part of the section were replaced by a numbered series extending downward from near the top of the formation (Oficina-1 sand) to the sand just above the A-B sand (Oficina-13 sand).

The Rho, Sigma, and Tau sands in the uppermost Freites formation and the lowermost part of the Las Piedras still retain their Greek-letter names and are of great importance in structure-drill work as constituting the first widely continuous marker horizons.

STRUCTURE

GENERAL

The Greater Oficina area is a segment of the southern limb of the Eastern Venezuelan structural basin (Fig. 8 in section on Stratigraphy). The axis of this basin trends east-northeast and plunges gently in the same direction. Consequently, regional dip over most of the Greater Oficina area is essentially north although it changes gradually to north-northeast in the western part of the area as beds tend to swing across the rising western end of the basin. Such data as are available on the basement surface indicate a slope of about 2°, but this applies only to the southern part of the area where basement was reached. The over-all angle of regional dip on the top of the Oficina formation throughout the area is 2°–4° and shows a generally increasing slope toward the basin.

TABLE III

DATA ON FAULTS IN GREATER OFICINA AREA

FAULT NAME	FIELD	DISTRICT	DOWNTHROWN BASINWARD	STRIKE	DIRECTION OF DIP	DIP	LARGEST KNOWN DISPLACEMENT	KNOWN LENGTH KILOMETERS	ACCUMULATION ON	ASSISTANT ACCUMULATION CONTROLLERS
MATAPALO	AGUA CLARA & YS-14	YOPALES	NO	N20°-35°W	SW	±36°	60'	17	N upthrown side	Agua Clara & YS-14 Branch Faults and eastward pinchout.
AGUA CLARA BRANCH	AGUA CLARA	YOPALES	YES	±E-W	N	(±45)	120	2	N downthrown side	Matapalo Fault.
YS-14 BRANCH	YS-14	YOPALES	YES	±E-W	N	(±45)	(50)	2	N downthrown side	Matapalo Fault.
YS-16 FAULT		YOPALES	NO	N30-50W	SW	(±45)	40	12	Not completely tested	
MOQUETE	MOQUETE	YOPALES	NO	NW-SE	SW	(±45)	80	4	NE upthrown side	Moquete Branch Fault.
MOQUETE BRANCH	MOQUETE	YOPALES	YES	NE-SW	NW	(±45)	50	1½	Both sides	Moquete Fault.
CARIS	OFICINA	OFICINA	YES	N80W	NE	±35	365	11½	Both but mainly N downthrown side	Formational closure, Branch Faults K & N and westward pinchouts.
BRANCH K	OFICINA	OFICINA	YES	N40W	NE	(±45)	70	1	Both sides	Caris Fault and formational closure.
BRANCH M	OFICINA	OFICINA	YES	N85-40E	NW	±45	120	4	Both sides	Caris Fault, westward pinchouts and Branch Fault N.
OFICINA	OFICINA	OFICINA	NO	N45-85E	SE	56-40	190	7	N upthrown side	Branch Fault E, formational closure and westward pinchouts.
BRANCH E	OFICINA	OFICINA	NO	N50W	SW	±50	70	2	Mainly N upthrown side	Oficina Fault and formational closure.
F	OFICINA	OFICINA	YES	E-W	N	±50	130	1½	Both sides	Westward pinchout.
TIGRE	OFICINA	OFICINA	NO	N65W	SW	45-40	200	4¾	N upthrown side	Formational closure and Hollywood Fault.
HOLLYWOOD	OFICINA	OFICINA	NO	N60E	SE	±45	90	3¼	Both sides	Tigre Fault and westward pinchout.
A	OFICINA	OFICINA	NO	N80-80W	SW	±50	155	9	N upthrown side	Fault B.
B	OFICINA	OFICINA	YES	N85-60W	NE	±45	90	3½	Both sides	Fault A and westward pinchouts.
MERCEDES	OC-202	OFICINA	NO	±E-W	S	56-40	200	4¼	N upthrown side	Branch faulting and westward pinchouts.
R	OC-202	OFICINA	NO	N75E	SE	±50	110	2¼	N upthrown side	Fault S and westward pinchouts.
S	OC-202	OFICINA	NO	N30W	SW	(±45)	100	4¼	NE upthrown side	Fault R and Mercedes Fault.
T	OC-202	OFICINA	YES	±E-W	N	±45	115	1¾	N downthrown side	Westward pinchout.
AVENTAZON	AVENTAZON	OFICINA	NO	N30-40W	SW	(±45)	75	104	NE upthrown side	OM-2 and OM-3 Branch Faults.

T	OG-202	OFICINA	YES	±E-W	N	±45	115	1¼	N downthrown side	Westward pinchout.

AVENTAZON	AVENTAZON	OFICINA	NO	N30-40W	SW	(±45)	75	10±	NE upthrown side	GM-2 and GM-3 Branch Faults.
GM-3 BRANCH	AVENTAZON	OFICINA	YES	E-W	N	(±45)	70	2	Both sides	Aventazon Fault.
GM-8 FAULT	AVENTAZON	OFICINA	NO	N70W	SW	(±45)	(50)	2±	NE upthrown side	Aventazon Fault.
WEST GUARA	WEST GUARA	GUARA	NO	±E-W	S	±45	500	14±	N upthrown side	Formational closure and westward pinchouts.
LAYME	NIPA	NIPA	NO	±E-W	S	(±45)	100	10	N upthrown side	Westward Pinchout?
GUARA-LEONA	E. GUARA & LEONA	GUARA & LEONA	YES	N65-65E	N	42-50	1400	43±	Both but mainly N downthrown side	Mainly branch faults on both sides plus some westward pinchouts.
GM-2 BRANCH	-	GUARA	YES	±N60W	NE	±45	100	3	NE downthrown side	Guara-Leona Fault and NE dip.
GS-20 BRANCH	EAST GUARA	GUARA	YES	N40W	NE	(±45)	±200	5	NE downthrown side	Guara-Leona Fault and N dip.
GM-3 BRANCH	EAST GUARA	GUARA	NO	(N60E)	SW	(±45)	170	?	Insufficient data	-
GS-33 BRANCH	EAST GUARA	GUARA	YES	±N70W	NE	(±50)	130	2±	None known	-
GG-50 BRANCH	EAST GUARA	GUARA	YES	±N50W	NE	(±45)	70	1±	Both sides	Guara-Leona Fault and NW dip.
GG-30 (M) BRANCH	EAST GUARA	GUARA	YES	N40W	NE	±50	150	3±	Both sides	Guara-Leona Fault and NW dip.
URUSPIA BRANCH	EAST GUARA	GUARA	YES	N70-89W	NE	45-70	350	2	Both sides	Guara-Leona Fault, NW and NE dip and westward pinchout.
GS-21 BRANCH	EAST GUARA	GUARA	NO	S60E	SW	(±45)	±250	3±	NE upthrown side	Guara-Leona Fault and NW dip.
GUIRIPAL	LEONA	LEONA	NO	E-W to N70E	S	±45	420	5±	Both sides	Westward pinchouts as far as known.
MEREY	ARBO-MEREY	MEREY	YES	N60E (Assumed)	NW	(±45)	300	10±	N downthrown side	Not known.

The area is one of relatively mild deformation, but the gentle regional dip is broken by a rather intricate system of laterally discontinuous normal faults (Fig. 2 and Table III). One set of these approximately parallels the regional contours of the basin, showing an east-northeast strike which in the western part of the area swings to an east or even east-southeast strike. The other set shows a distinct northwest trend. These faults appear to be largely tensional and the first set at least appears to be related to basinward subsidence. However, while many of the major faults are downthrown on their basinward side, many others are upthrown toward the regional basin. Such a phenomenon appears to be a not uncommon adjustment to regional basinward subsidence (as in the case of the Mexia and Balcones fault zones of Texas). Differential uplift and warping of the Guayana shield relative to the Eastern Venezuelan basin produced a zone of tension along the southern edge of the basin near the place where the basement surface begins to fall markedly. The tensional pull toward the south, opposing the tensional pull northward toward the basin, tended to produce a graben in this zone of maximum flexure. Instead of breaking in two simple faults, the one at the south with upthrow toward the south and the one at the north with upthrow toward the north, a series of more or less parallel laterally discontinuous faults was formed in which the total upthrow toward the south was approximately balanced by upthrow toward the north.

The largest displacement and the greatest lateral persistence in the Greater Oficina area is associated with the Guara-Leona fault which is downthrown toward the basin. This fault has been traced for more than 40 kilometers (24 miles) from its western extremity near the San Tomé terminal eastward through the Leona field. The throw of the fault increases from west to east, reaching 1,400 feet in the Leona field. The total extent of the fault in this direction is unknown. The eastward increase in throw is to a large extent accomplished by branch faults on either side of the main fault; these branch faults step down toward the east on the north side of the main fault and step up toward the east on the south side of the main fault. The branch faults ordinarily meet the main fault at angles of about 50°–60°, the acute angle opening toward the west on the north side and toward the east on the south side. Near its western extremity the main fault branches and swings toward the north.

Other large faults with basinward downthrow are the Caris fault (south of the Oficina field) and the Merey fault, 20 kilometers south of the Guara-Leona fault. Both of these faults in general parallel the contour of the regional basin. The Caris fault has been traced more than 11 kilometers and the Merey fault may extend more than 20 kilometers.

The more important of the faults with upthrow on the basinward side are the West Guara fault, which has been traced more than 14 kilometers, and has a maximum throw of 500 feet; the Oficina fault, traced 7 kilometers with a maximum throw of 190 feet; the Guiripal fault, traced more than 5 kilometers with a maximum throw of 420 feet; and the Matapalo, YS-16, and Aventazon faults

which appear to extend more than 10 kilometers, although no very great throw has been established for them.

The faults of the Greater Oficina area are in general characterized by dip angles of about 45°, regardless of the direction of throw. (The Caris and Matapalo fault planes locally dip as low as 35° and the Uruspia fault, a branch of the Guara-Leona fault, has a dip as high as 70°.) There is ordinarily very little drag, and disturbance of bedding is confined to within a few feet of the fault plane. In cored sections, this disturbance is manifested by steep and irregular dips and fracturing, and is most pronounced above the fault plane. The fault planes flatten slightly with depth.

The most important criterion of faulting is the abrupt cutting-out of intervals in the well and structure-drill sections. Although the presence of faults in the area was first established by detailed lithologic and paleontologic correlation, it is safe to say that without the continuous records of the electric logs only a small part of the faults known to-day would have been discovered. Other important criteria of faulting are changes in dip and strike of strata, variations in the accumulation of oil and gas, and pressure differences. Structure-drill work has revealed the presence of faulting through changes in regional dip, even though actual displacement is not present at structure-drill horizons. Abrupt increase in regional dip has meant faulting with basinward downthrow, and reversals or flattening of regional dip have meant faulting with basinward upthrow. The reflection seismograph has been successful in showing faults through misclosure of loops, zones of poor or disturbed records, and through abrupt changes in dip.

With regard to the time of faulting, it appears that some fault movements started in Oficina time and that considerable movement on most faults took place as late as Las Piedras time. In general, very little systematic variation has been established in the amount of throw of individual faults at different horizons from the base of the Oficina up to the base of the Las Piedras formation. However, within the Las Piedras formation, displacement commonly dies out in a short distance upward and is rarely discernible in the overlying Mesa formation. Even the large Guara-Leona fault does not appear to affect the Mesa surface. In rare cases, however, faulting which has been identified in the Oficina formation is either not discernible at all in the Freites formation or is reflected only as gentle folding in that formation. Moreover, in the case of the West Guara fault, there is an abrupt change in amount of throw above the top of the Oficina formation. While the West Guara fault continues up into Las Piedras horizons, the throw in the Freites formation is only about half as great as in the Oficina formation. It thus appears that in the Greater Oficina area some faulting occurred during Oficina and Freites deposition, but movements were particularly pronounced during Las Piedras time. A continually thickening section on the northern downthrown side of the Guara-Leona fault in the Leona district, where cores indicate nearly flat dip on both sides of the fault, suggests that this fault was continuously active through Oficina, Freites, and part of Las Piedras sedimentation.

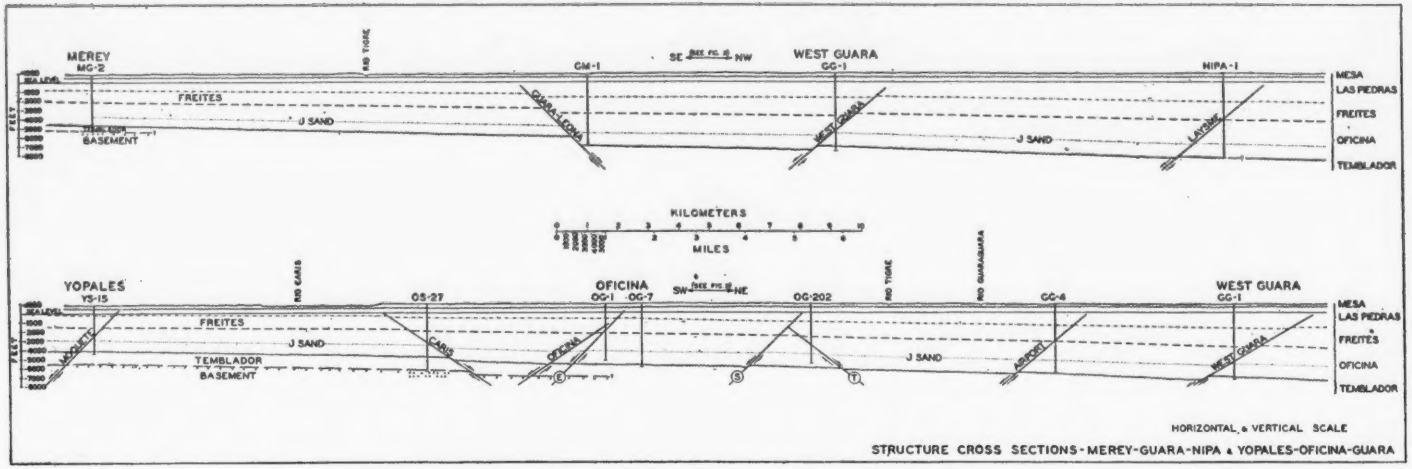


FIG. 10.—Structure cross sections. Merey-Guara-Nipa and Yopales-Officina-Guara.

Folding is of secondary importance to faulting in the Greater Oficina area and consists largely of very gentle noses and swales superimposed on the regional dip. These are probably in large part either the result of differential compaction or due to adjustments to faulting. Many of the wrinkles seen in the Freites and Las Piedras formations are actually the reflections of faulting at greater depth.

Whereas the over-all regional strike of the area (neglecting faulting) may be considered east-west, the actual strike of beds within individual fault blocks is dominantly northwest-southeast.

Figure 10 includes two structure sections to normal scale across the Greater Oficina area, one from YS-15 through the Oficina and West Guara fields and the other from Merey No. 2 through the Guara district and Nipa No. 1. The two lines of cross section are indicated in Figure 2.

GEOLOGIC HISTORY

In pre-Cretaceous time a peneplain was developed across the varied igneous and metamorphic rocks forming the basement of the Greater Oficina area. The age of this peneplain is not positively fixed, but since it cuts across sediments of supposed Jurassic age (Carrizal formation) just west of the Greater Oficina area, it may be late Jurassic or early Cretaceous in age.

Subsidence began in early Cretaceous time. In the Greater Oficina area, on the northern flank of the Guayana shield, deposition began with the non-marine arkosic sands, conglomerates, and mottled clays of the Temblador formation of probably Lower Cretaceous age. These sediments were obviously derived directly from erosion of the basement complex of the Guayana shield and the weathered residual material which had accumulated on that shield. The Cretaceous sea gradually encroached on the Greater Oficina area and the sandstones, glauconites, limestones, and shales of the upper Temblador were deposited in alternating brackish-water and marine conditions along the shores of this sea. These deposits may be time equivalents of not only the middle, but much of the upper part of the Cretaceous section known farther north along the Caribbean mountain front.

Whether deposition continued into Tertiary (Paleocene) time is not known, but either in the late Cretaceous or in the Paleocene, the sea withdrew as a result of gentle uplift of the Guayana shield and, during Eocene and early Oligocene time, the area suffered mild erosion which laid bare the basement rocks immediately south of the Greater Oficina area and beveled the very slightly tilted Temblador formation in the area itself. Such local deposition as may have occurred above the Temblador formation was largely of a transient nature until in Oligocene time downwarping of the Orinoco geosyncline at the north again gradually brought the area progressively from north to south below the base level of erosion.

The initial deposits of the Oficina formation were probably in large part derived from reworking of the Temblador formation, the brackish to marine environment at the borders of the Oligocene sea was not dissimilar to that of

Temblador deposition, and the angular relation of the two formations is so slight as to be hardly discernible. Consequently, the Temblador-Oficina unconformity is disappointingly vague and ill defined in individual well sections and the change upward from Cretaceous to Oligocene sediments in many places may be definitely established only with the appearance of the first marine Oligocene fossil invertebrates. Both the upper Temblador and the basal Oficina formations are characterized by thick and laterally variable sands so that electrical-log correlation fails as a guide at this point.

Deposition of the Oficina formation continued through Oligocene-Miocene time with repeated alternations of shallow-water marine, brackish marine, and coal-swamp environments. The picture of the Greater Oficina area during the deposition of the Oficina formation is that of a gradually subsiding area of very low relief across which the sea alternately advanced and retreated. Slight changes in sea-level brought extensive transgressions and regressions, but the shoreline lay generally on the south and west. The landward side of the strand line was the site of the deltaic deposition of a broad and many channeled river system comparable with that of the present Orinoco delta. The open-water area adjacent to the land was always shallow and of varying salinity, depending on the influx of fresh water from the tributary rivers. It was never part of the open ocean coast, but always a marginal segment of the great Orinoco Gulf. This gulf extended inland between the Guayana shield on the south and the Parian borderland on the north, and opened eastward to the Atlantic beyond Trinidad. Broad sheet sands alternating with mud were laid down in this body of water through the reworking and redistribution of the sediment brought in by the rivers. Locally, bar and channel sands were formed by shore currents and submarine rivers.

The shores of the Oficina sea appear to have been covered with heavy vegetation which accumulated in extensive swamps and bogs to form the numerous and persistent lignites of this formation.

Although crustal conditions were generally very uniform and quiet except for the sinking of the basin, there is some indication that minor folds were formed during Oficina time. These may have been largely the result of differential compaction. Some tensional faulting also probably occurred as an adjustment to the sinking of the basin. Near the close of Oficina time, there appears to have been a period of relative crustal unrest throughout the Orinoco geosyncline which was manifested in the Greater Oficina area by an increased amount of tension faulting and by the rather abrupt change of conditions seen in the change to Freites formation deposition.

The beginning of Freites time was marked by a definite change to sustained marine deposition in the Greater Oficina area, evidently resulting from an extensive westward transgression of the marine waters of the Orinoco Gulf beyond their limits in Oficina time. At the same time, there was a marked reduction in the amount of carbonaceous matter deposited or at least in the amount preserved in the sediments. The sediments change from gray to green and the abundant

lignites of the Oficina formation are missing from the Freites. The lower Freites shows numerous glauconitic sands, and an abundant and varied shallow-water marine fauna, and there may have been an uplift of border areas and acceleration of erosion concomitant with the greater depression of the basin and the more extensive encroachment of the sea. The extensive lowland swamp conditions which furnished the abundant organic matter of the Oficina sediments no longer existed.

As westward transgression of this gulf continued, the Greater Oficina area became farther removed from shore and the thick uniform deposit of green mud was laid down, which to-day forms the more than 1,000-foot thickness of typical Freites shale. Throughout the latter course of this deposition, however, the water of the gulf began to grow more brackish as evidenced by the gradual change in character of the fauna. Toward the close of Freites time, an approach to near-shore conditions is again indicated by the appearance of thin sands in the uppermost part of the formation, while at the same time marine fossils gradually disappear from the record.

In upper Miocene time, marked crustal disturbances took place along the northern border of the Orinoco Gulf, the sea withdrew completely from the Greater Oficina area, and the Las Piedras deposits which follow conformably above the Freites shale are typical fine-grained deltaic-estuarine deposits formed by large rivers emptying into a fresh to brackish body of water opening eastward into the sea.

Pronounced tensional faulting occurred and the bulk of the movement on the faults, which are of so much economic importance in the area to-day, took place at this time. Most of this faulting appears to die out within the Las Piedras and Algarrobo formations.

The Algarrobo formation represents a final phase of Sacacual deposition in which fluvial sands and claystones become predominant. Sacacual deposition was then brought to a close in Pliocene time by uplift of the whole Eastern Venezuelan region, with a shifting of the waters of the Orinoco Gulf far eastward of the Greater Oficina area. Coarse alluvial deposits derived from the rising mountains at the north and west were spread across much of the Eastern Venezuelan basin, while less material was derived from the Guayana shield area on the south. The axis of this basin apparently lay near the present course of the Guanipa River, so that most of the sediments of the Greater Oficina area were derived from the south and west. Locally, the initial Mesa deposits are reworked Sacacual or stream and eolian deposits laid down in perfect conformity with the Sacacual. Elsewhere, Mesa streams cut deeply into the Sacacual surface before filling their channels with sediment, and erosional unconformity is pronounced.

The Mesa sediment was built up to a depositional plain and under arid or semi-arid conditions ground-water evaporation formed an iron oxide hard-pan which now constitutes the cap rock of erosional remnants such as the hills near San Tomé. Rejuvenation of stream erosion by further uplift led to the formation

of a lower Mesa plain sloping toward the main east-west drainage systems. On this plain, during a period of aridity, a cap rock of residual and reworked material cemented by iron oxide was developed to form the capping of the extensive Mesa surface of the present day. Recent uplift and increased rainfall have led to the present era of erosion which is rapidly dissecting the Mesa surface.

OIL AND GAS RESERVOIRS

All of the commercial oil and gas reservoirs known to date in the greater Oficina area are sandstone bodies in the Oficina formation. This formation consists in large part of 3,000 feet of interlaminated and interbedded sandstones and shales. Beds of sandstone (potential reservoir rocks) aggregate 30 per cent of this total thickness, and are present in individual well sections as 50–70 distinct beds distributed throughout the formation and separated one from another by intervening shales and claystones. The sandstone bodies that contain oil and gas are not limited to any one part of this thick formation. Sandstones in every part of the formation are productive in at least some part of the area, under favorable structural conditions.

Fortunately, correlation throughout the area has been good enough to allow a single system of sand nomenclature to be applied to all of the several fields. This nomenclature was started in the Oficina field where the uppermost producing sand in the early stages of development was known as the A sand, and underlying groups of sands were designated as the B, C, D, *et cetera*, down to the U sands near the base of the formation. Many of these groups were then broken down into individual sands, for example, the F_1, F_2, F_3, F_4, *et cetera*, or the upper J, middle J, and lower J. Sands above the A sand through the upper part of the Oficina formation and on to the top of the Freites formation were originally considered non-productive, but merely for correlation purposes were given letters from the Greek alphabet in order upward from the Alpha sand to the Tau sand. Later, however, with the discovery of commercial oil in these upper Oficina sands in the Guara fields, a separate nomenclature replacing the Greek letters was devised for them. Starting just below the Theta sand (uppermost sand in the Oficina formation), they were named the Oficina-1, Oficina-2, Oficina-3 sand, *et cetera*, down to the Oficina-13 sand just above the A sand. This is admittedly a rather clumsy system of nomenclature which could, of course, have been improved if there had been foreknowledge of the great number of productive sands which would eventually be encountered, but on the whole it has been satisfactory. Sand nomenclature is shown graphically in the typical columnar section (Fig. 9 in the section on Correlation).

Electrical-log correlation of sands from well to well has been excellent, and in the various fields under development has allowed the preparation of structure maps and isopach maps on the numerous individual sand bodies. The isopach maps disclose that some of the individual sands are broad sheet-like bodies of more or less constant thickness over areas of tens of square kilometers. Others

are narrow elongate shoe-string or channel sands which attain thicknesses of 20–70 feet along their major axes, but shale-out on both sides within distances of only a few hundred meters. Though most of the sand bodies seem to belong in one of these two classes, some are intermediate in character.

In general, all of these sand bodies, large and small, rise gently and rather uniformly southward and southwestward out of the Eastern Venezuelan basin, and in an updip direction they either grade laterally into less marine sediments of a different facies, or are truncated in this direction by local unconformities associated with the Oligocene-Miocene shoreline. To complete the picture, these sand bodies are transected in many places throughout the area by the fault system previously described.

Under the circumstances, the original oil or gas content, if any, of these sands would normally be flushed updip by movement in that direction of water from the compacting sediments of the basin, and both strike faulting and pinch-out would present possibilities for the formation of traps for the commercial accumulation of petroleum, since either or both would present effective barriers to updip migration. Actually, the rather intricate system of faulting developed in the area has resulted in the presence of many fault traps and combination stratigraphic-structural traps. Furthermore, this faulting has divided individual fields into numerous segments. Consequently, every sand in every segment must be considered as a separate unit as regards accumulation and production. Since each segment may contain a considerable number of productive sand bodies, it may readily be realized that there are many individual reservoirs in each field. This condition is a characteristic of the area. Table IV summarizes the number of sands, segments, and reservoirs for each of the fields of the Greater Oficina area.

The structure-contour and isopach maps presented in the final section of this report afford a picture of the types and variety of reservoirs actually under exploitation. Figure 12 shows isopachs and contours on the very interesting and very important L_1 sand reservoirs of the Oficina field. These are combination stratigraphic-structural reservoirs where sand pinch-out is responsible for the seal on both the east and west, while faulting provides the seal on the south. Water is downdip below the oil on the north. The "D" segment of this sand is by far the largest single body of oil outlined to date in the entire Greater Oficina area. Figure 13 shows the P sand of the Oficina field. The accumulations shown for this sand are typical fault-angle traps. Figure 14, depicting four of the larger reservoirs of the West Guara field, illustrates closure and accumulation along a single strike-fault barrier, in large part due to the arcuate character of that barrier concave to the direction of regional dip. The four reservoirs there depicted bring out the manner in which this same structural feature is repeated down the section from sand to sand, resulting in multiple-zone accumulation. Figure 15 presents a cross section of this field.

Accumulation in East Guara is closely related to the big Guara-Leona strike fault with its numerous cross faults and resulting fault-angle traps. Figure 16

TABLE IV

TABULATION OF SANDS, SEGMENTS AND RESERVOIRS IN THE GREATER OFICINA FIELDS

Field	District	Drilled Wells	Number of Sands	Number of Segments	Number of Reservoirs
YS-1	Yopales	1	1	1	1
Agua Clara	Yopales	10	2	2	2
YS-11	Yopales	2	3	1	3
YS-14	Yopales	1	±8	1	±8
Moquete	Yopales	4	8	2	11
Oficina Proper	Oficina	256	36	15	111
OG-202	Oficina	39	24	4	42
Aventazon	Oficina	5	5	3	7
GS-13	Guara	2	1	1	1
West Guara	Guara	113[a]	47	1	50
GM-2	Guara	1	1	1	1
East Guara	Guara	37	35	7	76
GS-21	Guara	1	4	1	4
Leona	Leona	24	11	3	17
Merey Area	Merey	5	5	2	5
Nipa	Nipa	1	1	1	1
		502[a]	65[b]	46	340
Wildcat Dry Holes		10			
		512 [a]			

[a] Includes 20 wells drilled by Socony Vacuum of Venezuela

[b] Sands present in more than one field included only once in total

presents structure contours on two of the prominent East Guara sands. Note that three reservoirs are represented for the one sand, and four for the other. The Leona field (Fig. 17) is also related to strike faulting, but sand pinch-out has been an important adjunct. Accumulation in the LG-13 area in Leona is of interest as it seems to be due to the transection of a basinward-plunging nose.

The reservoirs pictured in the various figures are representative of the types of accumulation commonly found in the Greater Oficina area. The only domal accumulations yet discovered are small features closely associated with the Guara-Leona fault (Fig. 16).

It is obvious that faulting has played the major role in the accumulations discovered to date. From an exploratory viewpoint, faulting has been given the most attention because it lends itself to well established methods (seismograph and structure drill) and because a favorable fault pattern that might result in accumulation in one sand would be favorably repeated in many other prospective sands in the same well, giving rise to multiple objectives—*multiple possibilities of discovery*, in contrast to the single objective commonly found in strictly stratigraphic-trap accumulations. For these reasons almost all long step-outs and wildcats have been based on evidences or suggestions of faulting. Consequently, most of the reservoirs discovered in this area are fault-trap reservoirs. An important number are combined stratigraphic-structural reservoirs, but only a very few are strictly stratigraphic traps. It must be said, however, that more strictly stratigraphic-trap reservoirs no doubt are present in this area, and these will eventually be found one by one as exploratory and step-out drilling continue.

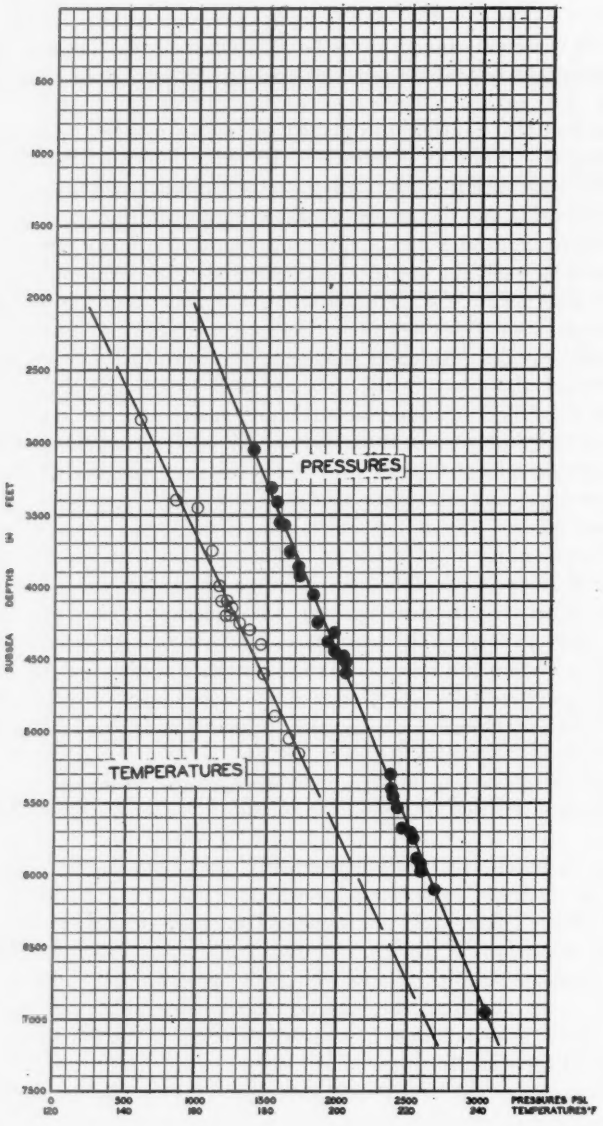
The total known productive area amounts to 25,740 acres. Commercially productive sands range in thickness up to slightly more than 100 feet. The thickness of the oil zones (vertical distance from gas-oil contact to oil-water contact) varies from practically zero to 550 feet. Lithologically, the sands are all soft, compacted, and show very little evidence of any secondary cementation. They are variable in sorting, grade-size, and clay content. The very best producing beds are soft, clean, well sorted medium-grained sandstones with porosities approaching 30 per cent and permeabilities of several thousand millidarcys. The more common producing beds are fairly clean, but very poorly sorted sandstones with porosities of 20–25 per cent and permeabilities ranging from 300 to 1,000 millidarcys. Silt-size particles are present in important percentages in only a few of the sands.

Most of the productive sands appear fairly well on the resistivity curve of the electrical log. Notable exceptions, however, are the D and E sands and locally the P sand of the Oficina field and some of the upper Oficina sands of the West Guara field, which, even where productive, exhibit very low resistivities. These low resistivities are due to comparatively high connate-water contents, probably resulting in large part from the presence of a considerable percentage of clay-sized particles or shale laminae interspersed throughout the coarser-grained clastic material of these sands.

Statistical data on the more important reservoirs known to date in the Greater Oficina area (original reserves of 5 million barrels or more) are given in Table V.

RESERVOIR PRESSURES

Measured virgin reservoir pressures throughout the Greater Oficina area, after adjustment downward at individual oil gradients to individual oil-water



RELATION OF RESERVOIR TEMPERATURES AND PRESSURES TO DEPTH

FIG. 11.—Relation of reservoir temperatures and pressures to depth.

contacts, have been found to be essentially a straight-line function of depth. Figure 11 plots some measured pressures in virgin reservoirs against depths subsea in feet. According to this plot, pressures between reservoirs increase with increasing depth subsea at a rate of 0.42 psi (pound per square inch) per foot. This slope, based on actual pressure measurements, is in close agreement with the calculated hydrostatic gradient for this area, which slowly decreases from 0.43 psi per foot at 1,000 feet to 0.42 psi per foot at 7,000 feet, in accordance with corrections for temperature, dissolved solids, and compressibility. It may be said, therefore, that virgin reservoir pressures in this area are related one to another and increase on essentially a hydrostatic gradient with increasing depths subdatum.

Extrapolation upward of the pressure data of Figure 11 suggests that the water table should lie at approximately 200 feet above sea-level. However, the water table in the shallow Mesa and Sacacual sands is actually 700–1,000 feet above sea-level in this area. Apparently the pressures plotted in Figure 11, all of which are from the Oficina formation underlying the thick Freites shale, are not in equilibrium with the hydrostatic pressures evidenced by the water table in the younger, non-marine, fluvial, and lacustrine beds which overlie this shale. The Freites shale seems to have acted as an effective barrier to the establishment of complete hydrostatic equilibrium within the geologic column.

RESERVOIR TEMPERATURES

Reservoir temperatures in the Greater Oficina area range from 140°F. to more than 200°F. and in individual fields tend to increase rather regularly with increasing depth. Figure 11 includes a plot of such data for the Oficina field proper, the indicated gradient being 1°F. increase in temperature per 51 feet of increased depth. The other fields have closely comparable gradients, but temperatures through the petroliferous section for a given subsea depth in Yopales seem to be 9°F. higher than temperatures in Oficina, and temperatures in Oficina 13°F. higher than temperatures in Guara. For given depths subsea, reservoir temperatures notably decrease from southwest to northeast over distances measured in only tens of kilometers. The component of regional dip in that direction is no doubt related to this effect, but perhaps other structural factors have also contributed.

RESERVOIR FLUIDS

OILS

All the oils produced to date from the Greater Oficina area are dark oils that existed in their respective reservoirs in the fluid state, that is, there has been no straight condensate production. The more than 340 known reservoirs contain a great variety of crudes most of which are classified as of intermediate base, but which collectively exhibit particularly wide ranges in physical properties. For instance, gravities vary from heavier-than-water tar-oil, through almost every intermediate value, to 57° API; pour points vary from below −50°F. to +95°F.;

TABLE V
DATA ON RESERVOIRS CONTAINING MORE THAN 5.000.000 BARRELS OF OIL-GREATER OFICINA AREA

	OFICINA PROPER					WEST GUARA						LEONA
SAND	C_L	L_1	L_4	P	S	D_3	D_4	F_5	F_7	H	M_U	G
SEGMENT	C	D	C	C	C	W. Guara	W. Guara	W. Guara	W. Guara	W. Guara	W. Guara	North
FORM	Lentic.	Channel	Lentic.	Sheet	Sheet	Sheet	Sheet	Sheet	Lentic.	Sheet	Sheet	Lentic.
RANGE IN NET THICKNESS (FEET)	0-28	0-73	0-56	10-48	48-110	20-63	27-56	14-26	0-108	48-60	10-60	15-33
AVERAGE NET SAND (FEET)	18	34	42	26	51	42	39	17	57	34	46	26
PRODUCTIVE ACRES - OIL ONLY	907	3,361	608	1,505	705	674	446	2,051	1,218	1,050	736	1,095
PRODUCTIVE ACRE-FEET - OIL ONLY	16,326	114,274	25,284	39,130	35,853	28,448	17,246	35,721	69,986	35,808	33,680	28,883
TOP OF RESERVOIR (FEET SUBSEA)	3,125	3,825	4,350	4,600	4,840	4,390	4,470	4,900	4,950	5,180	5,740	6,485
GAS-OIL CONTACT (FEET SUBSEA)	-	3,950	4,440	-	4,910	4,448	4,515	4,9757	5,000	5,270	5,810	?
OIL-WATER CONTACT (FEET SUBSEA)	3,307	4,500	4,600	4,885	5,030	4,582	4,621	±5,250	5,240	5,405	5,987	6,5859
OIL ZONE THICKNESS (FEET)	182	550	160	285	120	140	106	275	240	135	177	1607
AVERAGE EFFECTIVE POROSITY (%)	25	21	25	23.5	30	30	30	27	30	27	25	22
CONNATE WATER (%)	20	16	25	9	25	15	15	25	15	20	20	20
INITIAL GAS-OIL RATIO (CU FT/BBL)	340	750	360	665	390	725	860	600	1,050	895	700	460
SHRINKAGE FACTOR (%)	80	72	80	77	80	63	60	72	60	62	77	80
API GRAVITY RANGE IN RESERVOIR	24-35	35-39	10-22	20-30	14-21	37-44	40-45	22-41	39-43	36-42	10-26	28
API GRAVITY AVERAGE (PRODUCED OIL)	25	37	20	28	18	41	42	33	41	40	23	28
INITIAL CLOSED IN BOTTOM HOLE PRESSURE AT RESERVOIR MIDPOINT	1,455	1,865	2,015	2,115	2,210	2,010	2,043	2,275	2,270	2,375	2,610	2,860
CLOSED IN BHP - JANUARY 1, 1946		1,233	1,573	997	2,120	1,909	1,865		2,039	2,089	2,229	
TEMPERATURE AT MIDPOINT (° F)	152	170	177	182	186	163	164	174	174	179	190	201
TOTAL RECOVERABLE OIL IN RESERVOIR	5,877,360	33,710,830	7,332,360	12,521,600	12,548,550	12,403,328	7,157,090	6,072,570	29,044,190	11,172,096	12,091,120	6,222,260
PRODUCTION TO JANUARY 1,1946	2,330,231	22,397,891	2,682,396	7,696,606	4,041,668	1,388,312	2,568,603	49,329	5,851,172	3,086,065	3,731,529	31,071

and percentages of paraffine wax by weight vary from values of less than 0.5 per cent to more than 15 per cent. The sulphur content of each crude seems to be related to its gravity. The 40°–45° API oils contain less than 0.5 per cent sulphur; the 25°–30°API oils contain about 1.2 per cent sulphur; and 15°–20° API oils contain 2.3 per cent sulphur. A composite sample of the 36,700,000 barrels of crude oil produced from this area during 1945 would have a gravity of 33.9° API and a sulphur content of about 0.7 per cent.

Physical properties of 28 individual crude oils from this area are listed in Tables VI, VII, and VIII. These tables include some distillation data.

Any crude oil containing more than 4 per cent paraffine wax by weight is locally considered a "wax-oil." Such oils, though constituting only 3.6 per cent of the total production to date, have very recently become of increasing importance and are currently contributing 9 per cent of the monthly production of the area. This is largely coming from newly discovered shallow sands in the West Guara field. These so-called "wax-oils" in general have a gravity lighter than 35° API. Their wax contents vary from 4 per cent to more than 15 per cent and their pour points are correspondingly high. These oils are blended with non-wax production and thus present no serious problem in pipe-lining or storage. The physical properties of E_u sand oil from the Oficina field are listed in Table VI and those of Oficina-6_u sand oil and C sand oil from the West Guara field are listed in Table VII. These three oils are representative of the wax-oils of this area.

Tar-oil zones are present in the lower parts of the section in some segments in almost every field and tar-oil zones have very commonly been encountered in wildcat well sections drilled south of the area. At least one of these wildcat wells is reported to have flowed 50 barrels per day of 8.6° API oil while on test of a zone below 3,700 feet, before being plugged and temporarily abandoned. These heavy tar-oils have not been exploited, the lower limit of the gravity of production being about 15° API. However, the physical properties of two representative tar-oils (U sand oil, Oficina field, and P sand oil, West Guara field) are included in the tables.

In general, oil gravities in the Greater Oficina area decrease with increasing depth. But there are many exceptions and in exploratory drilling all parts of the Oficina formation down to and including the U sand are given consideration as prospects for the discovery of commercial production, that is, some sands in the lower part of the section do contain attractive light oils.

It is of particular interest that crudes of certain physical properties are not limited in occurrence to single sands, or to single fault segments, or to single localities. In fact, wide variations in physical properties of Greater Oficina area crudes occur (1) between different sands in the same fault segment, (2) in the same sand in different fault segments, and (3) in the same sand in a single fault segment, that is, within a single reservoir.

An example of the first case is the West Guara field where more than 30 reservoirs, one on top of another in close stratigraphic succession, sealed off

TABLE VI
PHYSICAL PROPERTIES OF
REPRESENTATIVE CRUDE OILS
OFICINA FIELD

SAND	C	E_U	F_S	J_M	L_I	M	N	P	S	U
Well	00-103	00-6	00-5	00-41	00-74	00-9	00-42	00-38	00-24	00-96
Gravity, API	25.5	36.7	34.0	37.3	35.7	32.5	35.9	29.2	16.1	8.3
Sulfur, B., percent	0.55	0.14	0.83	0.72	0.47	0.92	0.96	1.29	2.69	3.57
Saybolt Viscosity	67.5 (a)	37.2 (b)	45.0 (a)	38.1 (a)	36.0 (a)	47.3 (a)	38.6 (a)	61.9 (a)	5237. (a)	1397. (c)
Pour Point, F	10	95	-30	-5	below -50	below -50	below -50	below -50	10	60
Flash Point, O.C., F	below 60	65	below 60	below 60	below 60	below 60	below 60	below 60	85	225
Color	dark brown	bnk green	dark brown	dark brown	brown	dark brown	dark brown	dark brown	dark brown	black
% Motor Gas Distillate (over to 392 F)	15.8	28.9	30.0	42.0	32.8	29.5	44.8	31.2	13.6	2.7
Gravity, API	49.5	57.7	58.3	56.3	52.3	55.6	55.1	54.7	56.6	48.8
Octane Number, CFR-ASTM	66	60	55	55	57	54	54	54	58	58
% Heavy Blend Distillate (392-428 F)	3.9	2.9	4.0	4.8	5.1	4.1	4.8	3.7	2.2	1.1
Gravity, API	36.1	36.3	42.8	43.0	41.6	43.1	43.3	42.3	40.2	37.9
% Light Gas Oil Distillate (428-518 F)	13.2	9.8	12.2	9.2	14.8	11.8	9.9	9.7	6.0	4.4
Gravity, API	31.1	31.2	37.9	38.4	36.6	38.3	38.4	37.2	35.2	32.3
% Bottoms	66.9	58.2	53.5	42.7	46.9	54.2	38.6	54.5	77.6	91.1
Gravity, API	19.9	30.6	21.9	20.4	25.7	20.4	16.0	15.7	9.0	6.3
Saybolt Viscosity	51.3 (c)	40.5 (c)	499. (c)	616. (c)	43. (c)	659. (c)	3421. (c)	4177. (c)	3700. (c)	4544. (c)
Sulfur, B., percent	0.74	0.22	1.31	1.40	0.86	1.53	2.23	2.12	3.22	3.80
Pour Point, F	45	120	50	25	75	20	45	15	80	95
Carbon Residue, percent	3.15	5.99	6.50	6.04	2.49	6.56	9.66	11.5	12.3	18.8
% Loss	0.2	1.2	0.3	1.3	0.4	0.4	1.9	0.9	0.6	0.7
% Wax (by weight)	1.0	12.9	1.3	1.1	3.4	0.7	0.3	x	x	x
% Asphaltic Hydrocarbons	20.	20.	55.	57.	48.	57.	57.	51.	41.	26.
Base of Crude, UOPM	not given	Naphthene-paraffin	Intermediate	Intermediate	not given	Intermediate	Intermediate	Intermediate	not given	not given

(a) Viscosity at 100 F
(b) Viscosity at 122 F
(c) Viscosity at 210 F

TABLE VII
PHYSICAL PROPERTIES OF REPRESENTATIVE CRUDE OILS WEST GUARA FIELD

SAND	Of_{6U}	C	D_3	F_7	H	I_2	M_U	P
Well	WGG-63	WGG-63	WGG-44	WGG-25	WGG-34	WGG-54	WGG-3	WGG-64
Gravity, API	46.1	40.2	41.1	42.2	41.5	36.1	23.9	11.7
Sulfur, B., percent	0.16	0.28	0.40	0.31	0.36	0.47	1.79	2.70
Saybolt Viscosity	32.0 (a)	37.6 (a)	35.2 (a)	32.4 (a)	33.6 (a)	39.6 (a)	195. (a)	32,306. (a)
Pour Point, F	35	55	below -50	below -50	-35	-15	below 0	40.
Flash Point, O.C., F	below 60	below 60	below 60	below 60	below 60	below 60	70	120
Color	dark green	dark green	dark green	dark green	dark green	dark green	dark brown	dark brown
% Motor Gas Distillate (over to 392 F)	52.6	36.6	41.8	47.6	42.8	30.0	21.3	3.2
Gravity, API	61.4	56.7	57.8	55.4	57.6	55.5	55.1	53.5
Octane Number, CFR-ASTM	57	57	57	55	56	57	55	57
% Heavy Blend Distillate (392-428 F)	3.3	3.7	5.1	6.0	4.6	4.2	3.0	0.9
Gravity, API	39.3	41.3	42.1	42.2	41.8	42.0	41.6	38.3
% Light Gas Oil Distillate (428-518 F)	10.0	11.3	12.3	13.6	13.1	13.7	6.8	4.6
Gravity, API	33.5	35.9	37.2	37.4	37.7	36.8	36.6	33.1
% Bottoms	33.7	48.1	38.9	31.3	37.8	51.5	67.7	90.6
Gravity, API	30.2	27.8	25.9	25.5	25.6	25.4	13.0	10.0
Saybolt Viscosity	57.8 (b)	80.0 (b)	85.0 (b)	82.3 (b)	92.3 (b)	96.0 (b)	395. (c)	2598. (c)
Sulfur, B., percent	0.24	0.49	0.72	0.82	0.72	0.76	2.35	2.93
Pour Point, F	110	105	55	55	70	75	55	95
Carbon Residue, percent	1.17	1.82	2.03	2.58	2.48	2.58	13.9	17.7
% Loss	0.4	0.3	1.9	1.5	1.7	0.6	1.2	0.7
% Wax (by weight)	7.7	15.6	2.1	2.3	1.9	2.6	x	x
Base of Crude, USBM	not given	not given	not given	not given	not given	not given	Intermediate	not given

(a) Viscosity at 100 F (b) Viscosity at 130 F (c) Viscosity at 210 F

TABLE VIII
PHYSICAL PROPERTIES OF REPRESENTATIVE CRUDE OILS

	EAST GUARA FIELD				LEONA		YOPALES		AREO MEREY	
SAND	O_1	AB	F_{2-3}	F_{4-7}	I_1	I_2	J	S	F	J
Well	EGS-16	EGS-7	EGS-7	EGS-22	LG-1	LG-2	YS-2	YS-17	AREO-1	MG-1
Gravity, API	23.8	35.1	28.3	29.0	27.2	29.0	25.0	25.2	15.1	17.5
Sulfur, B., percent	1.49	0.68	1.08	0.98	1.26	1.08	1.08	1.14	1.96	2.04
Saybolt Viscosity	171.3 (a)	43.2 (a)	63.5 (a)	62.5 (a)	84.4 (a)	66.2 (a)	112.2 (a)	73.5 (a)	3313. (a)	1015. (a)
Pour Point, F	15	below -50	below -30	-15	-35	-40	-45	below -50	-10	-20
Flash Point, O.C., F	below 60	below 60	below 60	below 60	below 60	below 60	100	below 60	370	185
Color	dark brown	dark green	dark brown	dark brown	dark brown	dark brown	dark brown	dark brown	dark brown	dark brown
% Motor Gas Distillate (over to 392 F)	17.0	29.5	21.2	20.7	18.2	20.8	13.7	18.1	-	8.2
Gravity, API	53.8	58.8	54.8	53.8	56.7	56.4	49.0	49.0	-	49.2
Octane Number, C/R-ASTM	62	54	55	56	55	55	64	69	-	not given
% Heavy Blend Distillate (392-428 F)	2.4	3.7	3.9	3.2	2.7	3.6	3.1	4.2	0.4 (d)	1.9
Gravity, API	38.6	41.8	41.1	41.2	41.7	41.5	37.1	36.6	36.8	39.2
% Light Gas Oil Distillate (428-518 F)	8.5	10.8	10.3	11.2	10.6	10.8	10.6	11.5	7.1	8.7
Gravity, API	33.0	37.2	36.4	36.2	36.9	36.7	32.3	31.7	32.6	34.5
% Bottoms	71.4	54.7	64.0	63.3	68.0	63.7	71.6	66.0	92.2	81.0
Gravity, API	16.9	23.1	19.8	20.0	18.6	19.4	20.6	18.5	13.8	12.9
Saybolt Viscosity	560. (b)	383. (a)	286. (b)	275. (b)	1176. (a)	388. (b)	286. (b)	282. (b)	211. (c)	355. (c)
Sulfur, B., percent	1.98	1.1	1.54	1.46	1.79	1.71	1.24	1.58	2.13	2.22
Pour Point, F	50	25	30	40	15	15	50	30	30	40
Carbon Residue, percent	10.42	3.63	5.83	6.76	7.35	6.60	5.83	7.44	5.56	11.9
% Loss	0.7	1.3	0.6	1.6	0.5	1.1	1.0	0.2	0.3	0.2
% Wax (by weight)	3.3	x	x	2.3	0.5	1.1	x	0.2	x	x
% Asphaltic Hydrocarbons	not given	not given	not given	not given	50	49	not given	not given	28	38
Base of Crude, UOM	not given	not given	not given	not given	not given	not given	Naphthene-Intermediate	not given	not given	not given

(a) Viscosity at 100 F (b) Viscosity at 130 F (c) Viscosity at 210 F (d) Over to 428 F

updip by the same single fault, contain many different oils, both wax and non-wax, and with a complete range of production gravities from 16° to 57° API. A more complete description of this field is given in the final section of this report (Figs. 14 and 15).

An example of the second case is afforded by the S sand, a sheet sand prominent throughout the area. This sand produces 16° API oil in the Oficina field proper in the segment north of the Oficina fault, 41° API oil in the OG-116 area 7 kilometers west, 30° API oil in the OG-187 area 7 kilometers farther west, 25° API oil in YS-17 about 13 kilometers farther west, and 44° API wax-oil in YS-3 in the Agua Clara field. Here are at least five localities within a limited area which produce obviously different crudes from the same continuous stratigraphic zone, a zone averaging perhaps no more than 40 feet in thickness over the area represented. The five localities are all separated by faults, as well as by broad areas where this sand contains water alone.

An example of the third case is afforded by the M sand (upper member) of the West Guara field in which there seems to be a definite stratification of heavier and heavier oils with increasing depth. This particular accumulation is in a sheet sand 50 feet thick, and both horizontal and vertical permeabilities are excellent throughout. The reservoir covers about 1,500 acres. In this single reservoir the gravities of the oil produced from the various wells seem to change with increasing depth of perforations sub-sea and it is known that this reservoir grades into tar-oil downdip before passing into water. The data follow.

Well	*Subsea Depth (Feet) of Perforations*	*API Gravity of Production*
WGG-3	5,810–5,825	26.5
WGG-71	5,815–5,835	25.3
WGG-31	5,828–5,842	24.0
WGS-28	5,830–5,845	23.7
WGS-23	5,820–5,850	23.4
WGG-64	5,836–5,854	24.3
GV-5	5,825–5,862	23.3
WGG-10	5,850–5,875	23.7
WGG-1	5,860–5,870	21.7
WGG-67	5,858–5,878	23.1
WGG-21	5,857–5,891	21.7
GV-4	5,849–5,897	21.7
WGG-26	5,873–5,903	22.7
WGG-7	5,896–5,916	19.7
GV-3	5,891–5,918	19.1
WGG-20	5,897–5,917	17.0
WGG-67	5,906–5,916	18.1
GV-1	5,910–5,925	17.5
WGG-20	5,932–5,941[a]	12.0[a]
	Oil-water contact at 5,987 feet	

[a] This interval was not tested. The gravity is based on carbon tetrachloride extracts from a core.

Other examples of this phenomenon, wherein the powers of gravity segregation within a single fluid body seem to be stronger than the powers of diffusion through the body, are known in the Greater Oficina area. It seems significant that in all of these examples the lower limit is heavy tar-oil.

TABLE IX
SHRINKAGE AND DISSOLVED GAS VALUES DERIVED FROM ANALYSES OF BOTTOM HOLE SAMPLES OF VARIOUS RESERVOIR OILS

	Production Gravity API	Reservoir Temperature F	Original Reservoir Pressure	Sample Saturated With Gas ?	Shrinkage Factor	Formation Volume Factor	Dissolved Gas (a)
East Guara Field							
Theta Sand	20.8	142	1580	Yes	.92	1.09	180
Of-6_u	47.5	145	1658	Yes	.61	1.66	1080
Of-6_L	44.9	146	1647	Yes	.61	1.66	1065
Of-11	56.0	156	1839	No (b)	.55	1.82	1225
AB_1	39.3	155	1860	Yes	.67	1.49	900
C	38.5	160	1917	Yes	.64	1.56	1005
D_3	41.9	158	2034	Yes	.63	1.59	1015
D_4	44.0	161	2050	Yes	.60	1.67	1100
F_7	42.0	174	2250	Yes	.60	1.67	1100
H	40.6	177	2364	Yes	.62	1.61	1040
I_2	35.9	180	2412	Yes	.67	1.49	830
I_5	32.5	188	2460	Yes	.70	1.43	740
J_u	29.5	192	2563	Yes	.72	1.39	685
J_L	27.0	188	2560	Yes	.74	1.35	610
L_4	19.9	193	2596	Yes	.80	1.25	450
M_u	19.9	190	2596	Yes	.77	1.30	500
N_u	16.6	190	2617	No (c)	.87	1.15	230
East Guara Field							
Of-1	23.4	138	1900	Yes	.88	1.14	275
Of-2	28.6	154	1730	Yes	.83	1.20	365
Of-5	30.0	160	1960	Yes	.84	1.19	345
AB	35.2	163	2050	Yes	.72	1.39	690
F_1	29.1	179	2380	Yes	.76	1.32	565
F_7	29.8	184	2510	Yes	.76	1.32	570
F_8	28.9	184	2510	Yes	.76	1.32	570
J_L	30.7	189	2585	Yes	.75	1.33	570
Leona Field							
I_1-I_2	29.6	187	2454	Yes	.75	1.33	575
I_2	25.0	189	2445	Yes	.77	1.30	505
I_2-I_3	26.5	210	3052	Yes	.74	1.35	650
Oficina Field							
F_5	33.0	167	1830	Yes	.75	1.33	610
G	32.2	174	1940	Yes	.75	1.33	590
L_1	36.3	170	1856	Yes	.72	1.39	640
R_1	18.6	189	2240	Yes	.81	1.23	415
Topales Field							
J	25.5	156	1353	Yes	.90	1.11	195

(a) Dissolved gas in cubic feet per barrel of residual oil at 60 F
(b) Bubble point pressure is 924 psi.
(c) Bubble Point pressure is 1442 psi.

Bottom-hole samples have furnished additional information on the physical characteristics of many of the crudes. These samples have been collected in the early stages of flush production. With only a few exceptions these samples have been reservoir oils fully saturated with gas under reservoir conditions of temperature and pressure, indicating that these reservoirs are saturated reservoirs and that the reservoir fluid is in contact with at least some free gas (a gas cap) updip. Only two reservoirs (Oficina-11 sand and the upper N sand of West Guara) are definitely known to be undersaturated. Production experience has actually found initial gas caps on most of the reservoirs of this area and has found that only a very few reservoirs contain gas alone, with essentially no oil column. Shrinkage and dissolved gas values derived from laboratory analyses of bottom-hole samples from various reservoirs of the Greater Oficina area are presented in Table IX. Shrinkage factors vary all the way from 0.92 down to 0.55 and dissolved gas values range from 180 cubic feet per barrel up to 1,225 cubic feet per barrel.

The wide ranges in the many physical properties of the crude oils of this limited area are the more notable when one considers that all of these oils are present in the same geologic formation, are essentially the same geologic age, that practically all lie within the interval of 4,000–7,000 feet in depth, and that all have been subjected in large part to a common geologic history. It appears that the differences in character of these crudes must be almost entirely due to differences in local source materials. In another section of this paper, the idea of local source beds close to the present traps, requiring only a minimum of lateral migration along bedding, and requiring almost no vertical migration across bedding, is fully discussed. This is mentioned here because the wide variation in physical properties of the crude oils is one of the principal bases of reasoning behind it.

FORMATION WATERS

Table X presents chemical analyses of twelve formation waters from different sands through the petroliferous Oficina formation, grouped in order of increasing stratigraphic depth, and also a single analysis of a sample of water from the Rio Tigre representative of the type of water used in the area for all rig and camp purposes.

This table shows that in the formation waters of the uppermost producing beds, total dissolved salts amount to only 4,500 ppm (parts per million), and the concentration of chloride ion alone is only 600 ppm. Both figures are comparatively low for waters closely associated with commercial oil deposits. From these values as starting points, both figures increase with increasing stratigraphic depth, and in sands at about the middle of the Oficina formation (F sands) have attained values of 22,000 ppm and 10,000 ppm, respectively. Values of this order then persist through a great thickness of section, but near or below the S sand a sharp increase again takes place, and values approaching 34,000 ppm and 20,000 ppm, respectively, are attained at the base of the formation in the lowest beds currently under exploitation.

TABLE X
WATER ANALYSES
OFICINA AND WEST GUARA FIELDS
BY SANDS

	RIO TIGRE WATER	OF-$_7$	AB$_3$	Du	Du & Eu	F$_7$	H	Li	M	P	S	U	U
Parts Per Million													
Total dissolved solids	49	4429	4818	8536	11,051	22,290	22,686	21,225	20,795	21,765	23,908	35,849	35,196
Sodium (a)	14	1258	1355	3062	3,979	7,917	8,409	7,308	7,662	7,984	8,630	11,633	11,784
Calcium	3	46	35	42	37	137	70	159	109	148	325	938	884
Magnesium	2	23	24	25	60	73	66	98	34	85	82	185	165
Chloride	26	636	558	4252	5,544	10,513	12,086	9,256	10,875	11,630	13,048	19,806	19,680
Sulfate	6	141	64	128	0	149	9	tr	21	0	105	0	0
Bicarbonate	4	2325	2782	1012	1,431	3,501	2,946	4,422	2,092	1,966	1,714	1,089	744
Carbonate	0	0	0	0	0	0	0	0	0	0	0	0	0
Palmer Classification													
Chloride Salinity	85.2	85.9	91.9	97.8	100.0	99.0	99.9	100.0	99.9	100.0	99.4	100.0	100.0
Primary Salinity	66.1	35.4	27.2	87.7	86.9	84.0	91.0	78.3	90.0	91.9	92.9	89.3	89.9
Secondary Salinity	26.4	-	-	-	-	-	-	-	-	-	-	7.6	8.0
Primary Alkalinity	-	57.4	66.8	9.1	9.3	12.4	6.6	16.9	7.6	5.1	1.3	-	-
Secondary Alkalinity	7.5	7.2	6.0	3.2	3.8	3.6	2.4	4.8	2.4	3.9	5.8	3.1	2.1

(a) In every case sodium was only estimated by arbitrarily balancing reaction values.

NOTE: Analyses of waters from the Oficina-7 sand, from the AB$_3$ sand, and from the F$_7$ sand, are included by courtesy of the Socony Vacuum Oil Company of Venezuela.

Broad regional studies between fields have afforded evidence that the salinity of the waters of a given sand *decreases* from east to west, a fact in harmony with paleontologic data which indicate that marine beds are much more numerous in the Oficina formation in the eastern and central part of the area than in the west, that is, marine beds grade into brackish-water beds from east to west. The actual analyses presented in Table X are from the Oficina and West Guara fields. Values from East Guara and Leona situated at the east would be expected to be higher for given sands, while values from Yopales, situated at the west, would be considerably lower.

Actually, only 30 complete analyses of formation waters from the producing fields of this area have been made, but many hundreds of simple chloride determinations are available to supplement the picture. The data show that formation waters can be readily differentiated from drilling water or wash water by a simple quantitative determination of the concentration of chloride ion alone, and that this chloride determination can ordinarily afford some idea of the approximate source of the water in question, that is, whether it comes from high, intermediate, or low in the stratigraphic section. But many of the water problems associated with oil production call for the ready differentiation and identification of waters from adjacent sands less than 100 feet and perhaps even less than 50 feet apart, and available data do not give much encouragement that this can easily be done by the usual chemical analyses. For this reason, a set of representative formation waters was sent to the States for emission spectrographic analysis. This analysis included determinations of boron, silicon, magnesium, iron, aluminum, copper, sodium, calcium, barium, and strontium. Results suggested valuable possibilities but further research was necessary. Spectrographic analysis seems to have some obvious advantage over regular chemical analysis; it is more rapid, requires only a small quantity of water, and detects elements which can not readily be included in usual chemical analyses. In the fields of this area with their multiple pay zones and close intermingling of oil and water sands, the identification of water sources is particularly important and laboratory work toward this end must be expanded to meet increasing demands.

NOTES ON ORIGIN, MIGRATION, AND ACCUMULATION OF OIL

Regardless of the nature of the petroleum source material or the exact process of origin of the oil, there is fairly strong evidence that the oil produced in the fields of the Greater Oficina area originated within the Oligocene-Miocene Oficina formation—the same formation in which it is now found. The origin of this oil, therefore, is related to the accumulation of organic matter and its conversion to petroleum hydrocarbons in sediments of alternating shallow-water marine, brackish, and coastal swamp environments, deposited in a gradually subsiding synclinal basin in which broad sheet sands and less extensive channel sands were intercalated with carbonaceous muds, ligniferous material, clay-ironstones, and thin impure limestones. Moreover, there is also fairly strong evidence that the oil not

only originated within the Oficina formation, but very close stratigraphically to the reservoirs in which it now occurs and very close to the geographic areas where it is now being exploited. In other words, there has been extremely limited vertical migration across stratigraphic horizons and only moderate migration laterally along these horizons.

The writers believe that the multiple-sand character and intricate system of segments and reservoirs in the fields of this area present an exceptional opportunity for the study of matters concerning place of origin, migration, and accumulation of petroleum, not always afforded by simpler single-reservoir fields. Evidence for the origin of the Oficina oil at stratigraphic horizons very close to those in which it is at present found may be summarized as follows.

1. In spite of essentially conformable deposition, essentially identical age, and a common geological history, there is a marked variation in the character of the oils found in different sands within the same trap segment. This variation includes a range in gravities from less than 10° to 57° API, differences in wax content from a negligible amount to more than 15 per cent, differences in dissolved gas values, variations from undersaturated oil to all gas, and differences in color, sulphur content, and other qualities. Moreover, these variations show no more systematic relation to depth than is called for by the general changes in environment of deposition from bottom to top of the Oficina formation, and marked differences in these qualities are commonly found to occur from one sand to the next in the stratigraphic succession. A striking example is the presence of the highly waxy D and E sand production of the Oficina field in the middle part of the productive section, overlain and underlain by sands producing non-waxy oil.

2. Differences in the salinity of water associated with different sands in any one structural trap are not compatible with extensive migration from one bed to another or mixing of fluids across stratigraphic boundaries.

3. The persistent shale bodies which lie above and below the various sands of the Oficina formation should theoretically have served as effective barriers to vertical migration between sands.

4. The faults of the Greater Oficina area, while numerous, definitely have acted as barriers rather than avenues of migration (West Guara cross section, Figure 15).

5. Sands of the basal Freites formation immediately above the Oficina formation in the present fields invariably are barren of oil. These sands rest conformably on the Oficina formation and are separated by no greater shale barriers from the Oficina producing sands than separate these latter from each other. These basal Freites sands occupy the same relation to structural traps, are of essentially the same degree of continuity, and are covered by the same seal (Freites shale). It is hard to find any explanation of the absence of petroleum in the Freites formation in the present fields other than that source material was lacking.

6. The general tendency toward heavier oil with depth (although broken by

numerous exceptions) appears to accord with the general tendency toward more brackish and less marine environment of deposition toward the base of the Oficina formation.

7. Certain sands within the oil-producing section of the Oficina formation are locally barren of oil, although overlain and underlain by productive sands. The only reason for these differences, provided there is no leak in the fault barrier forming the trap, seems to be in the environment of deposition of the sands or of the adjacent shales.

Evidence for the geographically local origin of oil found at any particular horizon (limited lateral migration) is as follows.

1. There are marked changes in gravity and character of oil in individual sands from one area to another. For example, as mentioned in a previous section, the S sand produces 16° API oil in the segment just north of the Oficina fault, 41° API oil in the OG-116 area 7 kilometers distant, 30° API oil in the OG-187 area, 7 kilometers farther west, 25° API oil in YS-17, 13 kilometers still farther west, and 44° API wax-oil in the Agua Clara field. Yet electrical-log correlation shows that essentially the same sand is represented in all these cases.

2. Sands in the upper part of the Oficina formation are barren of oil in the southern and western parts of the Greater Oficina area in spite of favorable structural traps. These same sands contain oil farther north and east where more marine conditions apparently prevailed during the deposition of these beds.

3. Southward and westward from the Greater Oficina area where the whole Oficina formation becomes definitely less marine, heavy tar-oil replaces the lighter oils known in the Greater Oficina fields.

4. Oil is commonly found in the Greater Oficina area in lenticular sands of small lateral extent. It is difficult to see how it could have reached these sands by any extensive lateral migration.

Considering the evidence outlined, the writers are inclined to believe that the oil produced from the Greater Oficina area had its origin largely in the shales of the Oficina formation immediately above and below each of the productive sands and that it migrated laterally only moderate distances in these sands within the Greater Oficina area. It is not improbable that the dominantly gray color of the Oficina shales (finely divided carbonaceous matter) is significant with respect to its character as a petroleum source rock, since the principal difference between the Oficina shales (associated with oil-bearing sands) and the Freites shales (associated with barren sands) is the green color and lack of carbonaceous matter in the latter.

The process by which petroleum may have passed from the Oficina shales to the adjacent Oficina sands is of course a potentially controversial matter. However, it should be considered that these shales where deposited as muds with many times the volume which they now possess. Reduction to their present volume must have been accomplished chiefly through expulsion of water which probably passed into the associated sands carrying the petroleum with it.[6]

A possible argument against considering the Oficina formation as the sole source of oil in this area is the fact that oil staining (although no production) has commonly been encountered in the underlying Cretaceous Temblador formation. Some oil may have formed in this formation, but it is significant that many of the Temblador occurrences are in the definitely non-marine lower part of this formation in sediments which certainly have none of the commonly accepted qualities of source rock. It seems that much of this oil probably actually originated in the overlying Oficina formation and migrated either downward through the nearly continuous sand bodies of the basal Oficina into the Temblador sands, or migrated laterally to its present position in the Temblador formation from Oficina sands pinching out against the Temblador unconformity farther basinward.

Though the available data indicate relatively local areas of accumulation for the oil in the Oficina sands, they also definitely require a certain amount of lateral migration. This appears to have taken place in a radial direction away from the center of the Eastern Venezuelan basin, that is, dominantly in a southerly or southwesterly direction up regional dip in the Greater Oficina area. It is clearly evidenced by the fact that almost all accumulations are found on the basinward side of the barriers to such migration. These barriers are generally changes in permeability (pinch-out and fault seals) rather than folded structures. Since the principal faulting causing the accumulation did not occur until after the beginning of Las Piedras time, it is evident that while oil migration may have been taking place previously, it must have continued well into the time of Las Piedras deposition. It may be that extensive migration could not proceed until a certain dip gradient had been established in the Oficina formation by the combined results of compaction and basin subsidence. The concentration of oil accumulations in the steeply flexed zone between the nearly flat Guayana platform and the deeper part of the basin may be due, not only to the concentration of fault structures, but also to the relatively steeper inclination of beds here which favored updip migration. During the course of compaction and the escape of fluids from the Oficina formation, much oil was probably swept around the stratigraphic and structural barriers and lost at the southern edge of the basin. A part was caught in structurally favorable areas against barrier faults and another part was trapped in closed sand lenses. Production to date has been largely from the fault traps which can be discovered by normal structural exploration methods. It is probable

[6] The extent of this compaction (and water expulsion) has been previously discussed in considerable detail (H. D. Hedberg, "Gravitational Compaction of Clays and Shales," *Am. Jour. Sci.*, Vol. 31, 1936, pp. 253–61). Well AB, from which most of the data in this paper were derived, is actually the Oficina well No. 1. In the consolidation of the present Oficina strata (about 1 kilometer thick), 1 cubic kilometer of water (6 billion barrels) must have been squeezed out of the sediment for each square kilometer of areal extent, in order to reduce it from an initial average porosity of 60 per cent to a present average porosity of 20 per cent. Escape for this water was probably first to the sand bodies and then laterally along these up the regional dip to the southern and western borders of the basin. Considering the broad area covered by this formation, it is evident that a tremendous volume of water must have moved through these sand bodies and it can scarcely be doubted that this moving current of water must have played an important role in the migration and concentration of the relatively small amount of oil which also existed in the formation.

that many accumulations hidden in lenticular sands still remain undiscovered in the Greater Oficina area. With the increasing number of wells throughout the area and with further stratigraphic studies of the sands encountered in these wells, it may be possible in the future to predict successfully the location of many of these stratigraphic traps.

DRILLING AND COMPLETION PRACTICE

All wells in the Greater Oficina area have been drilled by the rotary method, generally with steam rigs. During recent years, eight to fifteen such rigs have usually been in operation. Drilling depths range from about 4,500 feet in the Agua Clara and Moquete fields of the Yopales district to 8,000 feet in the North Leona field, but are variable in individual fields due to faulting. Drilling is relatively easy. Drag-type bits are used down to about 3,500–4,000 feet, but below this depth the formations are sufficiently consolidated to warrant the continuous use of roller-type bits. Completion times on exploitation wells range from about 30 days for the shallow wells of the Yopales district to 75 days for the deeper Leona and Guara wells. Wells are in general drilled through the whole potentially productive section, but in West Guara a series of interspaced shallow wells penetrating only the upper sands has recently been started.

Considerable coring was done in the early exploration wells, but coring in exploitation wells is now confined to getting samples, where necessary, for sand and fluid analysis. One or two electrical surveys are made of each well and side-wall gun-sampling is routine procedure for evaluating doubtful intervals indicated by the electrical logs. The side-wall samples are studied particularly for indications of oil staining. The gravity of the oil causing any coloration of solvent is determined by use of an Abbe type refractometer, which in this area has been an indispensable tool in sand evaluations.[7]

Numerous casing programs have been tried during the history of development but now the most common program for exploitation wells calls for 600–1,000 feet of $10\frac{3}{4}$-inch or $9\frac{5}{8}$-inch surface casing and a 7-inch or $5\frac{1}{2}$-inch oil string to bottom. After a long history of unsatisfactory shut-offs with ordinary cementation methods, it is now general practice to use 2-stage cementation on all deeper wells having a long oil section. Squeeze jobs are then employed to insure shut-offs at critical points in the section. Completion is uniformly by gun-perforating, and dual- and triple-zone completions are common. Triple-zone completions in this area have recently been discussed in detail.[8] A practice of opening only a single sand to each zone has been rather strictly followed.

The relatively flat and open terrane of most of the area has allowed the skidding of rigs, derricks, boilers, and pumps from one location to the next, thereby

[7] H. D. Hedberg, "Evaluation of Petroleum in Oil Sands by Its Index of Refraction," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 21, No. 11 (November, 1937), pp. 1464–76; 3 figs.

[8] "Triple Zone Completions in Eastern Venezuela," *Oil and Gas Jour.*, Vol. 44, No. 34 (December 29, 1945), pp. 227–33.

saving considerable time and expense. Pictures of these operations have been presented in a trade journal.[9]

Because of the multiple-sand nature of the fields and the possibility of recompletion in a new sand as soon as the flowing life of an original completion sand has ended, several workover rigs are kept busy.

PRODUCTION

PRODUCTION PRACTICES

Well spacing has, in general, been according to the equilateral-triangle system. In the Oficina field, early development was on a 303- and 606-meter grid, giving drainage areas of 19.6 and 78.4 acres per well, respectively. Later, spacing was changed to 350 meters (26.2 acres) and finally standarized at 444.4 meters (42.3 acres). The over-all average drainage per well in this field is now about 50 acres. The Leona field was started on a 629.8- and 363.6-meter grid (drainage of 85.0 and 28.3 acres, respectively). Development in the Guara district and throughout the rest of the area during the last few years has been on a primary equilateral-triangle grid of 769.8 meters with potential break-down by face centering to 444.4 meters (42.3 acres) or 256.6 meters (14.1 acres). The closer spacing has been used in the thick multiple-sand areas adjacent to faults. Even with the 14-acre *well* completions, the drainage on individual sands is rarely less than 40 acres, that is, few adjacent wells on the 256.6-meter grid are completed in common sands.

The excellent correlation of individual sand bodies from well to well, which was first established by lithologic and paleontologic studies made possible by continuous cores and thereafter so easily carried on by means of Schlumberger logs alone, early afforded convincing evidence of the identity of individual sand bodies, and indicated that each accumulation in every individual sand body was apart from all other accumulations in the same well and had its own individual oil-water contact. These facts, coupled with knowledge that permeabilities varied greatly from sand to sand, dictated the practice of producing individual sands through individual conductors, which practice has been rather rigidly followed. This policy has been very largely responsible for the degree of control which has been maintained over water entries and gas entries into the reservoirs proper, and for the degree of success which has been achieved in maintaining clean oil production. This practice has also made possible information about the volumes of oil withdrawn from individual sand segments, and likewise the location of important volumes of oil that are being left behind in the ordinary production practices, but which will perhaps be available to secondary-recovery methods.

Each sand from which a well produces, or has produced, as an individual unit through an individual conductor, is locally termed a "zone." Production rates from each zone are restricted by individual surface chokes (usually $\frac{1}{4}$ inch) and

[9] G. D. Ives, "West Guara Field," *Oil Weekly*, Vol. 120, No. 1 (December 3, 1945), pp. 20 and 24, International Section.

initial rates per zone through this choke as a rule lie between 200 and 400 barrels per day. The wells flow the oil direct to field gathering stations, or to field manifolds and thence to the gathering stations. Two-stage separation is generally practiced, the first separators operating at 90 psi and the final separators at 45 psi. The stations are designed so that at least one individual production test including rate, gravity, cut, and gas-oil ratio can be made on each individual zone each month. The total oil received and gaged at each station each month is then allocated to individual zones and reservoirs on a basis of these individual production tests and hours on production.

At first, no segregation was made and all of the various Oficina oils were brought together into the same tanks at the gathering stations, and the gravity of the resulting "Oficina crude" averaged between 30° and 33° API. Late in 1940, various of the gathering stations in the Oficina field were modified to permit segregation of the lighter-gravity oils, in an effort to meet sales contracts for 35°–37° API oil. At almost the same time came the exploitation of the big "D" segment of the L_1 sand which contained 37° API oil and which assured success to the move. For some time thereafter a segregation of Oficina crudes was carried out, affording large quantities of two grades of oil for blendings and sales purposes. The so-called "Oficina light" oil averaged 35°–37° API, while the "Oficina heavy" oil, made up of the remainder of the production, averaged about 29° API.

During the latter half of 1943, Leona, East Guara, and West Guara were brought into production and their oils were pumped together through the combination 8–10–12-inch Leona pipeline to the Oficina tank farm where they were added to the "Oficina heavy" grade. Leona and East Guara production averaged about 29° API, but West Guara production was somewhat lighter, and became still lighter as development progressed to include more and more light-oil zones. As a consequence of West Guara's contribution, the gravity of "Oficina heavy" oil gradually rose from its initial of 29° API to 34° API. During this period, segregated "Oficina light" production of 35°–37° API continued to come from the Oficina field proper—largely from the L_1 sand, "D" segment. But the volumes of such oil available from this source were on the decline, and in September, 1945, a separate 8-inch line was put in operation between gathering station No. 3 in West Guara and the Oficina tank farm, which permitted easy segregation of a large quantity of light oil from the West Guara field. Since that time all requirements for "Oficina light" have been taken from West Guara, and the present (January 1, 1946) gravity of this so-called "Oficina light" is between 36° and 37° API. Light oil is no longer segregated in the Oficina field proper, and all of the production from that field, plus all of the production from East Guara and Leona, plus West Guara production from gathering station No. 1, plus the part of West Guara station No. 3 production not required for "light" goes together into the present so-called "Oficina heavy" grade, which now (January 1, 1946) averages 34°–35° API. This gravity could very easily be lowered by segregating a larger volume of "Oficina light" if such were required.

PRODUCTION DATA

As of January 1, 1946, 127,772,268 barrels of oil had been withdrawn from the Greater Oficina area from a total of 450 wells for an average cumulative production per well, on that date, of 284,000 barrels. From another viewpoint, this oil had been withdrawn from a total of 823 zones for an average cumulative production per zone on that date of 155,000 barrels. A large percentage of the wells, and perhaps 50 per cent of the zones included in the foregoing calculations are still on production. In the Oficina field, eight wells (Nos. 8, 22, 23, 24, 29, 46, 123, and 129) have already individually produced more than a million barrels of oil, and one zone, the F_5 sand in OG-29, has already produced more than a million barrels.

Production data for the several districts of the Greater Oficina area are summarized in Table XI. This table lists not only the production record by years for each of the 9 years that the area has been under exploitation, but also considerable additional information on number of wells drilled, number of producers, number of productive sands, number of individual reservoirs, productive surface acres, productive acre-feet, and so forth, as well as reserve estimates—all *by districts*.

Table XII lists cumulative production for each district *by sands*, excepting that the Guara district is represented by two separate columns, one for West Guara and one for East Guara. This table shows for each district the vertical range of stratigraphic section from which oil is being produced, the relative importance in each district of each *part* of the stratigraphic section insofar as productivity to date is concerned, and finally stands as supporting evidence of the statement made in an earlier section of this report to the effect that "sandstones in every part of the Oficina formation are productive in some part of the area, under favorable structural conditions."

PRODUCTION PROCESSES

A few of the reservoirs of the Oficina field have maintained fairly high bottom-hole pressures in spite of the production of substantial percentages of their total oil initially in place. These particular reservoirs have only small gas caps and seem to be producing under effective natural water drives. But this condition is exceptional in the Oficina field because of the lenticularity of so many of the productive sands and because of the complex faulting which breaks that field into so many small segments. Either pinch-outs or faults not far downdip below the oil will limit the volume of water lying in the same lithologic-structural unit in which the oil is trapped, and this volume of water below the oil must be large compared with the volume of oil initially in place before there can be any effective water drive. West Guara, with its thicker sand units, better permeabilities, and very simple faulting picture, offers much better water-drive possibilities than does Oficina, and bottom-hole pressures in the West Guara field are being watched with interest. Since most of the productive reservoirs have not been affected by water

drive because of lithological and structural limitations, and since almost all of them are saturated reservoirs with only small gas caps updip, they have produced to a very important degree under dissolved gas drive. However, by careful watching of gas-oil ratios and by restriction of rates of withdrawal, this process in many wells has been very materially aided by gravity drainage made possible by good horizontal and vertical permeabilities, and in some wells has been further aided by expanding gas caps.

PRESSURE MAINTENANCE AND SECONDARY RECOVERY

In an effort to attain the most economical production, attention has recently been directed to pressure-maintenance projects and to repressuring projects. A compressor plant, capable of injecting 30 million cubic feet of separator gas daily into the initial gas caps of four or five of the larger reservoirs of the West Guara field, is on order from the United States and should be in operation in 1947. In this field, several outstanding reservoirs are suitable for pressure maintenance by gas injection. Injections will be of a magnitude sufficient to retard greatly the decline of bottom-hole pressures at current production rates, thereby lengthening the flowing life of the wells. The gas to be injected is separator gas that is to-day being vented to the atmosphere because of lack of a market. The gasoline obtained as a result of the compression and interstage cooling will be stabilized for use in company transportation units, and any excess can be added to the crude stream as so many additional barrels of oil.

A second compression plant is on order to be erected in the Oficina field for injecting gas from one or two of the gas sands of that field into the gas caps of four or five partly depleted reservoirs, in an effort to prevent further reductions in pressure and thereby to lengthen the flowing life of the wells. In fields characterized by dual-zone and triple-zone completions, the maintenance of natural flow through the annulus and casing is an attractive goal. It is further hoped that benefits in ultimate recovery will be obtained by the prevention of further increases in the viscosities of the reservoir oils, as well as by the eventual sweeping action of the gas on its way toward outlet wells.

The injection of water downdip below the oil in partly depleted reservoirs, whose production performance indicates that only a small percentage of the oil in place will be recovered by ordinary processes, is also under study. The small "B" segment of the L_1 sand (Fig. 12), a narrow partly depleted lenticular reservoir in the Oficina field, sealed updip by faulting, has been selected for the first trial. The average porosity of this reservoir is 21 per cent and the average permeability is about 440 millidarcys. This reservoir produced under dissolved-gas drive only 20 per cent of its stock-tank oil in place, while pressures fell from 2,000 to 1,100 psi, and for some time not one of its eight wells has given satisfactory flowing production. The injection of 4,500 barrels per day of water downdip below the oil in an effort to flood the oil updip to producing wells by a general raising of the oil-water contact will be started in January, 1946. By keeping all potential pro-

TABLE XI
PRODUCTION DATA BY DISTRICTS

	YOPALES	OFICINA	GUARA	LECHA	MERET	OTHERS	TOTALS
WELLS DRILLED AS OF JANUARY 1, 1946	19	300	160	25	5	3	512
WELLS COMPLETED AS COMMERCIAL PRODUCERS	11	271	150	21	3	1	457
STATUS OF WELLS AS OF JANUARY 1, 1946							
ACTIVE							
NATURAL FLOW OIL WELLS	0	104	92	0	0	1	197
GAS WELLS	0	2	0	0	0	0	2
PUMPING WELLS	0	15	0	0	0	0	15
GAS LIFT	0	2	0	0	0	0	2
INACTIVE							
OIL WELLS BUT INSUFFICIENT STORAGE	5	14	44	16	1	0	80
GAS OR HIGH GAS/OIL RATIO	0	66	0	0	0	0	66
MECHANICAL REASONS	0	3	0	0	0	0	3
WATER CUT	2	5	4	0	0	0	11
DEAD	3	46	7	5	2	0	65
ABANDONED PRODUCERS	1	14	3	1	0	0	19
NON-COMMERCIAL PRODUCERS	3	0	0	0	1	0	3
ABANDONED DRY HOLES	5	29	10	3	1	2	51
NUMBER OF PRODUCTIVE SANDS	16	37	50	11	5	1	65
NUMBER OF PRODUCTIVE SEGMENTS	7	22	11	3	2	1	46
NUMBER OF INDIVIDUAL RESERVOIRS	25	160	132	17	5	1	340
RANGE IN PRODUCTIVE DEPTHS (FEET)	3000'-4600'	3160'-6600'	4300'-7600'	6035'-7700'	3700'-4926'	7104'-7138'	-
RANGE IN PRODUCTIVE SANDS	F - U	A-B - U	Oficina-1 - T	F_{2-3} - U	F - P	G	-
THICKEST OIL SAND (NET FEET)	30 (P)	110 (S)	108 (F_7)	33 (G)	25	25	-
THICKEST OIL ZONE (FEET)	±50	550 (L_1)	400± (F_{6-7})	350± (I_2)	?	?	-
RANGE IN API GRAVITY (PRODUCED OIL)	16°-42°	8°-46°	11°-57°	15°-40°	10°-19°	37°	-

PRODUCTIVE SURFACE ACRES (OIL)	895	13,215	4,810	5,310	1,470	40	25,740
PRODUCTIVE ACRES (INCLUDES OVERLAPS)	1,050	32,715	31,723	9,899	1,470	40	76,897
PRODUCTIVE ACRE-FEET	17,220	685,555	700,149	127,734	45,150	1,200	1,557,008
AVERAGE EFFICIENT INITIAL PRODUCTION RATE PER ZONE (BARRELS)	500	350	450	300	250	300	-
PRODUCTION DECLINE (% PER MONTH)	5	4	3	2.5	5	5	-
WITHDRAWAL TO DATE (BARRELS PER ACRE-FOOT)	10	137	43	27	1.5	3.5	-
CRUDE OIL DAILY POTENTIAL JANUARY 1, 1946	1,660	40,900	85,800	5,500	250	300	134,410
PRODUCTION RECORD BY YEARS (BARRELS)							
1937	-	20,017	-	-	33,380	-	53,397
1938	8,982	174,977	-	251	33,422	-	217,612
1939	-	2,347,642	-	-	198	-	2,347,840
1940	-	15,414,106	-	17,551	-	-	15,431,657
1941	-	24,460,485	4,920	82,298	-	-	24,547,703
1942	-	12,190,191	10,596	367,155	-	-	12,567,942
1943	23,263	9,707,156	698,007	854,790	-	-	11,283,216
1944	135,220	14,563,378	8,527,308	1,389,160	-	-	24,615,060
1945	-	15,259,677	20,710,928	733,044	-	4,192	36,707,841
TOTAL PRODUCTION	167,465	94,137,623	29,951,759	3,444,229	67,000	4,192	127,772,268
RESERVES AS OF JANUARY 1, 1946	3,750,285	92,626,057	161,602,377	24,182,921	13,929,500	395,808	296,486,948
PRODUCED OIL PLUS RESERVES	3,917,750	186,763,680	191,554,136	27,627,150	13,996,500	400,000	424,259,216
WELLS DRILLING JANUARY 1, 1946	0	1	11	0	0	3	15
MENE GRANDE OIL COMPANY	0	1	8	0	0	2	11
SOCONY VACUUM OF VENEZUELA	0	0	3	0	0	1	4

Included in Guara, Socony-Vacuum Has:

20 Wells	80,023 Productive Acre-Feet
815 Surface Acres	11,000 Barrels Potential
4,895 Productive Acres	2,663,353 Barrels Production

TABLE XII

ACCUMULATIVE PRODUCTION BY SANDS

AS OF JANUARY 1,1946

SAND	TOPALES	OFICINA	WEST GUARA	EAST GUARA	LEONA	TOTALS BY SANDS	TOTALS BY SAND GROUPS	GROUPS
Oficina-1				975,176		975,176	2,460,577	Upper Oficina
Oficina-2				8,473		8,473		
Oficina-4				36,814		36,814		
Oficina-5			28,250	36,807		56,057		
Oficina-6				205,763		205,763		
Oficina-6_u			54,674			54,674		
Oficina-6_m			1,368			1,368		
Oficina-6_l			17,771			17,771		
Oficina-7			169,975	353,471		523,446		
Oficina-11			156,044	422,991		579,035		
A-B		178,263		315,630		485,893	800,422	A-B
$A\text{-}B_1$			48,307			48,307		
$A\text{-}B_2$			53,221	59,114		112,335		
$A\text{-}B_3$			2,034	108,188		110,222		
$A\text{-}B_4$				43,675		43,675		
C		2,365,792	186,640			2,552,432	2,552,432	C
D		592,366		46,895		639,261	5,402,311	D
D1			141,512			141,512		
D2			64,623			64,623		
D3			1,988,312			1,988,312		
D4			2,568,603			2,568,603		
E_U		3,213,764	63,850	64,807		3,342,421	3,895,363	E
E_m			552,942			552,942		
$F_{1\text{-}2\text{-}3}$				594,712		594,712	17,295,843	F
$F_{2\text{-}3}$					2,853	2,853		
F3		32,873	93,840	82,480		209,193		
F4		480,042	68,051			488,094		
F5		7,091,619	60,353	15,706		7,167,677		
F6		67,306				67,306		
$F_{6\text{-}7}$				2,086,534		2,086,534		
F7			5,851,172			5,851,172		
F8		188,885	101,628	537,589		828,302		
G		418			341,059	341,477	341,477	G
H		67,804	3,086,065			3,153,869	3,153,869	H
I_1		443,675		186,747	504,297	1,114,719	5,637,058	I
$I_{1\text{-}2}$					197,528	197,528		
I_2		513,690	1,257,670		1,324,086	3,095,346		
$I_{2\text{-}3}$					682,918	682,918		
I_3		119,537				119,537		
I_4		2,748				2,748		
I_5		84,266	399,996			424,262		
J_u		414,619	277,621	34,619		727,059	8,258,283	J
J_m		4,596,717				4,596,717		
J_L	83,550	1,709,029	705,262	243,161	193,505	2,934,507		
L_1		28,529,156			25,042	28,554,198	35,419,786	L
L_2			949,227			949,227		
L_3		29,871	84,555			54,227		
L_4		5,443,850	418,283			5,862,133		
M_u		7,685,453	3,731,529	60,548		11,477,550	11,545,381	M
M_m			46,736		(M_3) 21,105	67,851		
N_u	8,982	2,913,092	290,345			3,212,419	4,961,472	N
N_L		1,749,053				1,749,053		
O_u		1,226,811				1,226,811	3,159,458	O
O_L		1,932,647				1,932,647		
P	C	11,102,547				11,102,547	11,102,547	P
Q	C	547,484				547,484	547,484	Q
R_1		1,716,567				1,716,567	4,505,499	R
R_3		999,910			49	999,959		
R_4		1,788,973				1,788,973		
S	74,933	5,468,075		C		5,543,008	5,543,008	S
T	C	640				640	640	T
U_1		447,724				447,724	1,118,167	U
U_2		89,349				89,349		
U_3		429,307			151,787	581,094		
TOTALS	167,465	94,137,623	33,484,640*	6,497,119	3,444,229	127,701,076*		
					Plus Mercy District	67,000		
					Plus Nipa District	4,192		
					GREATER OFICINA GRAND TOTAL	127,772,268*		

*Includes 2,683,355 barrels produced by Socony-Vacuum Oil Company of Venezuela.

C = Completion but no pipe line.

ducing wells shut in for a few months after the injection starts, it is hoped that the bottom-hole pressure will be built to a point where the wells will again flow, and that this pressure can then be maintained in the face of production. A small reservoir was purposely selected for this first trial in order that at least the trend of the results might be apparent within no more than 6 months or a year. Other projects of a similar nature are being planned.

OUTLET

The oils of the Greater Oficina area are pumped from the various gathering stations of the various fields to a central tank farm consisting of five 96,765-barrel tanks located just north of the Oficina field. From this tank farm the oil is pumped northward through a 16-inch pipeline to Puerto la Cruz on the Caribbean coast 155 kilometers away. The pipeline is coated with bitumastic enamel and wrapped with felt, and is buried approximately 18 inches under the ground. At Anaco, 58 kilometers north of the tank farm, there is an intermediate booster station and also four 96,765-barrel tanks for storage purposes, as well as for receipt of Anaco area crudes into the system. Elevations along the pipeline fall from a high of 1,025 feet at a point 3 miles north of the Oficina tank farm to 720 feet at the Anaco station, and on down to only 110 feet at a point just south of Boca Tigre. The line then crosses three sharp ridges, Boca Tigre, Cerro Grande, and Pele Ojo, with three abrupt rises and falls of 300–425 feet each before finally entering the Puerto la Cruz tank farm where the elevation is 20 feet.

The pump station at the Oficina tank farm is equipped with three Gould triplex double-acting plunger pumps $6\frac{3}{4}$ inches by 27 inches, powered by 500-horsepower gas-operated prime movers. This station is capable of handling 105,000 barrels of oil per day with a line pressure of 775 pounds. The Anaco station is similarly equipped, but with four such pumps. The Anaco station pumps direct to storage at Puerto la Cruz, where the Mene Grande Oil Company has fourteen 96,765-barrel tanks in service and six additional such tanks in construction. From this storage the oil is picked up with electrically driven centrifugal pumps and is pumped to ten 139,675-barrel loading tanks. It may then be loaded aboard tankers by gravity feed through 24-inch loading lines at a rate of about 12,000 barrels per hour.

The oil loading dock of the Mene Grande Oil Company at Puerto la Cruz is 1,328 feet long and has berths for two large tankers. There is more than 35 feet of water alongside. The first tanker to load at Puerto la Cruz was the "Gulfbird" on December 4, 1939. Since that time many tankers flying the flags of many companies and many nations have loaded at this dock.

Almost all of the production to date from the Greater Oficina area has been exported from Venezuela as crude. Somewhat more than 50 per cent of this crude has gone to refineries in the Dutch West Indies and approximately 35 per cent of it has gone to the east coast of the United States. The various destinations to January 1, 1946, are shown in the following table, with percentage of total volume shipped to each.

	Percentage
Curacao, Dutch West Indies	42.49
East Coast, United States	34.61
Aruba, Dutch West Indies	11.07
Canada	7.57[a]
England	1.81
Spain	.72
France	.70
Argentina	.36
Uruguay	.32
Brazil	.12
Netherlands	.11
Italy	.06
Sweden	.06
	100.00

[a] Includes oil landed in bond at Portland, Maine, and then sent to Canada *via* pipeline.

SUMMARY OF PRINCIPAL FEATURES OF INDIVIDUAL FIELDS

Inasmuch as the preceding part of this report has dealt with the area as a whole, information on individual districts and important fields is scattered; this final section is therefore devoted to the principal features of each district and the important fields therein.

YOPALES DISTRICT

Nineteen wells (all pooled Creole-Mene Grande) have been drilled in six separate parts of this district. Of the six wildcats, four have been completed as oil wells, one as a potential pumper and one (YS-16) as a dry hole. The location of the first wildcat was based on refraction-seismograph work, and the remainder were located on structure-drill features; reflection-seismograph mapping has not yet covered the district.

Production has amounted to only 167,465 barrels, mainly from the Agua Clara field. This field was shut in during 1945 because of lack of facilities for handling wet oil. The more recent discoveries, YS-14 and Moquete (YS-15), have not been produced because material has not been available for pipeline extensions.

The dominant fault system of the district (Fig. 2) is a series of long (10–17 kilometers) faults with a northwest strike and a dip southwest away from the basin. Displacements ordinarily are about 50 feet. At least two faults with east strike and north dip (downthrown basinward) are present on the upthrown basinward side of the Matapalo fault, and displacement on one of these east-west faults amounts to about 100 feet. There is some reason for believing that the east-west faults are the older because there is no evidence of one of them at shallow horizons, and the other does not affect shallow beds nearly as much as do the northwest-southeast faults.

The outstanding characteristic of the Yopales district is the extreme thinness of the oil zones. All producing oil sands are closely associated with gas or water, and clean, low gas-oil ratio wells rapidly go to gas or water on production. Complete data are not yet available on the YS-14 and Moquete areas because of no

pipeline connection, but it seems probable that similar unfavorable production characteristics will be found.

On the basis of continuous cores in YS-1, it is known that the Oficina formation in this district was deposited mainly in brackish water and that the many marine zones of the Oficina field are largely absent. This environment could affect accumulation in two ways. First, scarce marine source beds would permit formation of only small quantities of oil. Second, the extremely lenticular sands commonly deposited in an environment of this type furnish only small "pick-up" areas and would tend to divide the available oil into a considerable number of very limited reservoirs. Basinward faults and lenticularity of sands should practically eliminate updip migration of oil from more marine areas.

Basement was reached at 5,999 feet in YS-1. No other wells in the district have been drilled through the Temblador formation.

OFICINA DISTRICT

Three hundred wells (269 on Mene Grande leases and 31 on leases pooled with Creole) have been drilled in the 22 productive segments which are grouped together in the Oficina district. Of these wells, 271 were completed as commercial producers. After producing more than 94,000,000 barrels of oil, 118 wells are still flowing satisfactorily, 17 are on artificial lift, and 120 are closed in because of high gas-oil ratio, and other reasons or are dead; to complete the total, there are 2 gas wells, 14 abandoned producers, and 29 abandoned dry holes. A number of the closed-in wells will still furnish considerable production on work-over or artificial lift.

Largely because the drilling rigs were concentrated for several years around the OG-1 discovery well, and because more wells have been drilled here than in all other districts combined, the Oficina district, aside from having produced 75 per cent of the oil won from the area, leads in many other respects. The total of 13,215 productive surface acres exceeds the combined total of all other districts, and the total of the productive area of all individual sands—32,715 acres—exceeds that of any other district. The total of 22 productive segments is only two less than the total now known in the remaining districts; the extreme segmentation, along with 37 different productive sands, provides a record total of 160 individual reservoirs. Eight wells in the Oficina district have now each produced more than 1,000,000 barrels of oil; as yet, no other district contains a million-barrel well. Many dual-zone completions and one triple-zone completion have been made.

Following the completion of OG-1 and OG-2, both of which were located largely on refraction and torsion-balance work, and the abandonment of OG-3, which was considered as a more or less blind step-out from production, exploitation drilling began on a 1,200-meter grid surrounding OG-1 with additional 1,200-meter step-outs from several of the first 1,200-meter step-outs. Nine of these step-outs were completed before a dry hole was encountered. Since that time, step-

outs have usually been on a 606-, 444-, or 350-meter basis aside from the various wildcats drilled from time to time. The ambitious primary step-out program, with continuous cores through the petroliferous section on almost all wells, furnished a wealth of data on sand characteristics, environment, and faults, and was actually the most reliable type of exploration available in the central part of the Oficina district. After the presence of faults was well recognized reflection-seismograph mapping covered the area, and with the aid of subsurface data from the field, a technique in interpretation was developed which has been successful in this and in associated and similar districts. Structure-drill work has been carried out in the area surrounding the original wells and has been of considerable aid in establishing and tracing a number of the faults.

Faulting in the Oficina district includes a series of more or less east-west faults paralleling the basin, plus a second series of faults striking northwest. In some places the basinward side is downthrown and in other places the shoreward side is downthrown. Numerous small branch faults do not belong to either one of these major trends. From a regional viewpoint, it seems probable that the main reason for complexity is that this district is in the bend of the structural basin where the strike is beginning to swing toward the northwest.

The more important accumulations (AB through U) in the district are found on the basinward side of the faults, although some minor accumulations are present on the opposite side. The most important reservoir in the Greater Oficina area, the L_1 sand in the "D" segment (Fig. 12), is controlled by faulting across the updip end of the sand lens plus pinch-outs of the sand both east and west; this reservoir contains more than 33,000,000 barrels of recoverable reserves. Other reservoirs are controlled by similar structural-stratigraphic traps, but most of them are under structural control within closure formed by intersecting faults cutting across the southwestward rise of the basin.

OS-27 in southern Oficina encountered basement at 7,250 feet. No other well in the district has been drilled through the Temblador formation.

Oficina field proper (Fig. 12 and Fig. 13).—The term, "Oficina field proper," includes all Oficina district wells excepting those in the OG-202 and Aventazon fields; the term thus includes 256 wells (230 OG, 25 OS, and 1 OM). For ease in reference, the major segments of the field are designated by the first four letters of the alphabet, with directional sub-letters indicating certain other segments; these segments are shown in quote marks ("A", "B", "C", "D", "C_w", "C_n", *et cetera*) on the three Oficina structure maps included with this report (Figs. 2, 12, and 13). The "C" and "D" segments are by far the most important in the field. Certain other areas are referred to by their most important well (OG-187 area, OG-116 area, OS-11 area, *et cetera*).

Most of the reservoirs in the Oficina field proper are under combined solution and expanding gas-cap drive, although a few, such as the C sand in segment "C" had no gas caps and are dominantly under solution drive, and a few others, such

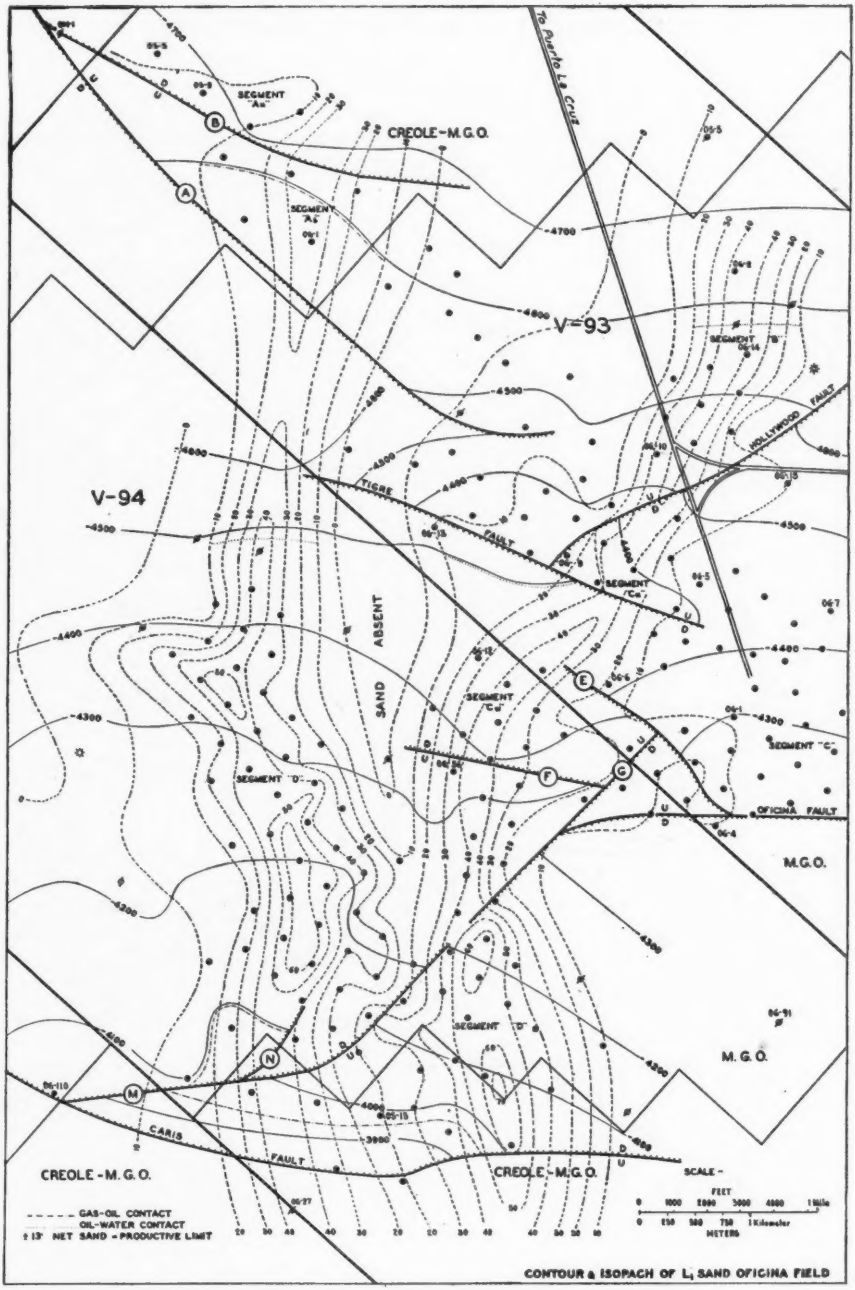


FIG. 12.—Contour and isopach of L_1 sand. Oficina field.

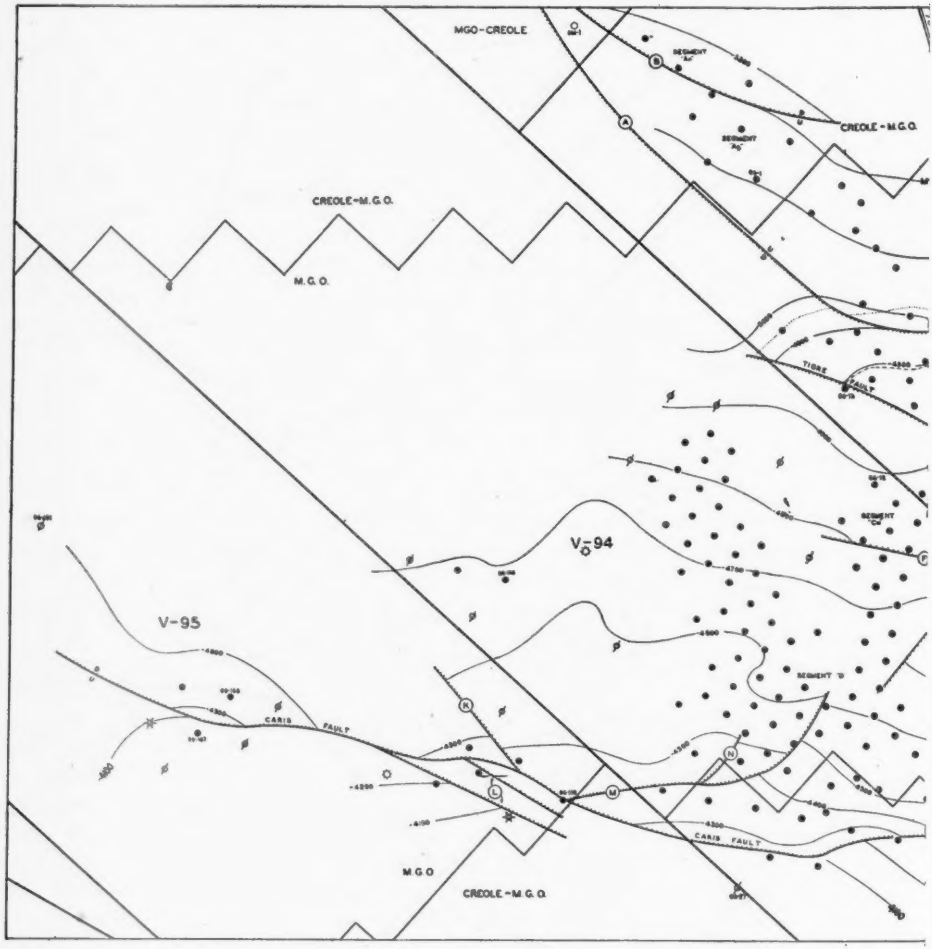
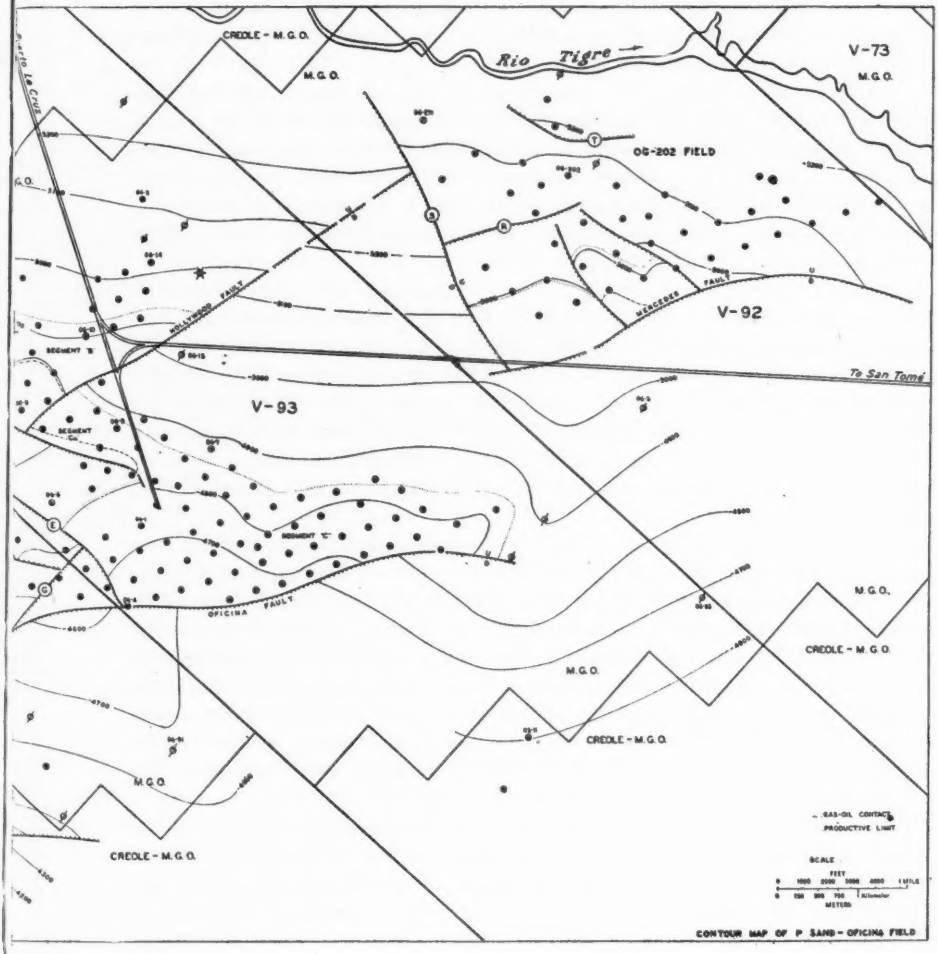


FIG. 13.—Contour map



of P sand. Oficina field.

as the M sand of segment "B" and the S sand of segment "C," are under effective water drive at present withdrawal rates. These water drives are in sheet sands where the combined effect of compaction of the sediments and expansion of the large water reservoir is apparently sufficient to replace the oil withdrawn from the relatively small oil reservoir.

A number of reservoirs in the field show a striking decrease in gravity of oil with descending position in the reservoir. This is best developed in the N_u and L_4 sands of segment "C" and in the L_1 sand of segment "C_w". The gravity variations have a range of 10°–15° in each of these reservoirs. Lesser variations have been noted in a considerable number of reservoirs. As a general rule, tar-oil cuts are obtained in the downdip wet parts of reservoirs regardless of the gravity of the produced oil.

The first flowing production in Eastern Venezuela of the peculiar so-called wax-oil was obtained in OG-5 of this field. Wax-oil is discussed in detail in the section on Fluids. At OG-5 on a drill-stem test in July, 1938, every one was amazed when the obviously light oil (±40° API) began to pile up on the derrick floor. Since that time, the novelty has worn off, because fields on the north of the Greater Oficina area producing nothing except wax-oil have been discovered. Nevertheless, the high wax content causing the peculiar properties of the oil is believed to be fairly unique. Only two sands in the Oficina field proper, the E_u and D, contain wax-oil.

OG-202 field (Fig. 13).—This field, discovered in 1941, has been the only portion of the district in which drilling has taken place during the past several years. The 37 completions and 2 dry holes, all on MGO leases, have been drilled mainly by one or two rigs, so development has been slow. The outstanding characteristic of this field is the extreme lenticularity of the many productive sands along with especially complex faulting. The combination of the two might suggest that some faulting occurred during deposition of the sands. Some wells drilled for certain sands do not find them, but new developments commonly compensate for the loss.

One F_s reservoir in this field passes abruptly from 36° API oil into dead tar-oil. No wax-oil sands have been encountered in this particular field.

Aventazon field.—The Aventazon field is of little present importance, but should produce considerable oil on exploitation. The five wells (4 OM, 1 OS), of which two have been abandoned, have obtained 16°–22° oil in the F and J groups (3,900–4,600 feet) and the relatively heavy gravity has stopped exploitation. One gas sand is present at 3,160 feet, the highest occurrence in the Oficina district. The controlling features are a long northwest-southeast fault (Aventazon) downthrown on the southwest plus several generally east-west faults. The structure here is thus very similar to that of the Yopales district.

GUARA DISTRICT

One hundred sixty wells have been drilled in the 11 known productive segments of the Guara district. Of these wells, 20 are on Socony-Vacuum of Vene-

zuela leases and were drilled by Socony, 76 are on Mene Grande leases, and 64 are on pooled leases belonging to Creole and Mene Grande; the latter 140 wells were drilled by and are operated by Mene Grande. Ten dry holes have been drilled (4 GG, 5 GS and 1 GM), of which 6 were wildcats and 4 were short step-outs from production. Dual- and triple-zone completions are made in practically all of the wells.

As of January 1, 1946, after producing more than 29,000,000 barrels of oil, 136 wells are satisfactory producers, 11 are closed, dead or water-cut, 3 are abandoned producers and 10 are dry holes. Very few zones are closed because of gas or high gas-oil ratio. Contributing factors to this record are an active work-over program which substitutes good sands for those that become wet or excessively gassy, and a relatively short production history, which did not get into full stride until 1944.

Largely because as many as 15 rigs have concentrated in this district during the past several years and because dual- and triple-zone wells are the rule, the build-up in potential has been very rapid. The potential of 85,800 barrels per day is almost twice as much as the combined potential of all other districts in the Greater Oficina area. The district also leads all others with its 50 productive sands and its 700,149 oil-productive acre-feet.

Following the 1942 completions of WGG-1 and EGG-2, both of which were discovered on the basis of reflection-seismograph work, a short step-out program limited by lack of materials was followed. However, in May, 1944, exploitation was proceeding rapidly with 9 rigs, and continued with as many as 15 rigs through most of 1945. Toward the end of 1945, several rigs were moved out of the Guara district to find new reserves. Structure-drill work in connection with reflection-seismograph data has been of particular value in delineating the many segments along the Guara-Leona fault.

None of the wells in the Guara district (excepting GS-13) has been continuously cored through the petroliferous section. However, especially in West Guara, the main producing sands have been spot-cored in various parts of the field for core analysis, reserve, and repressuring purposes.

The Guara district (Figs. 2 and 10) is dominated by two faults, the large West Guara fault and the very large Guara-Leona fault. This latter fault extends across the district, with increasing displacement toward the east edge of the district. The arcuate West Guara fault, cutting across structure contours, controls accumulation in the West Guara field, and the Guara-Leona fault, in conjunction with numerous small branch faults, controls the East Guara field. The Guara-Leona fault, which is downthrown basinward, is more than 43 kilometers long and has a displacement which increases from 300 feet in GS-13 to more than 1,400 feet in the Leona district. On the north side of the fault, all branch faults have a general northwest trend and are downthrown northeast; on the south side of the fault, all branch faults have a general southeast trend and are downthrown southwest. These downstepping faults on the downthrown side and upstepping faults on the

upthrown side account for the increasing displacement from west to east. There is reason to believe that the Guara-Leona fault was contemporaneous with deposition because stratigraphic intervals on the downthrown side in areas of known practically flat dip are consistently at least 10 per cent thicker than on the upthrown side. The West Guara fault, more than 14 kilometers long and with a displacement of as much as 500 feet, is downthrown on the south (toward the Guara-Leona fault). It seems probable that the west Guara fault is strictly an adjustment of the north side of the block downdropped along the Guara-Leona fault.

All of the important accumulations in the district are on the basinward side of both the West Guara and Guara-Leona faults; however, small accumulations are also known on the south side of both of these major barriers. Sand lenticularity and faulting control several of the 132 reservoirs, but most of the reservoirs are under structural control only.

Several wells have been drilled a short distance into the Temblador formation, which is at about 7,900 feet in WGG-1, but no wells have been drilled to basement. In West Guara, final depth is commonly near the M sand, although a number of interspaced wells are scheduled for completion just through the C sand. In East Guara, final depth is several hundred feet below the Guara Leona fault.

The only presently important fields in the Guara district are the West Guara and East Guara fields. Three one-well fields are present at GS-13, GM-2 and GS-21, all of which are associated with the Guara-Leona fault and therefore could be included in the East Guara field.

West Guara field (Figs. 14 and 15).—Of the 113 wells (57 GG, 36 GS, and 20 GV) so far drilled in this field, only one has been an abandoned dry hole. The unique, at least for the Greater Oficina area, characteristic of the West Guara field is simplicity. The one structural segment and 47 productive sands also make it an extremely compact field; this is shown by the fact that 460,287 acre-feet of oil sand underlie only 2,980 surface acres, making an over-all average of about 155 feet of net oil sand per acre. The geographical location of this rich field, which is only 5 kilometers north of the main Mene Grande camp of San Tomé, was of great importance during the war years when transportation facilities were extremely limited. The field is 8 kilometers long and 1½ kilometers wide.

In the heart of the field, the petroliferous section in any one well is as much as 2,600 feet thick. This great thickness of alternating shales and gas or oil sands has called for considerable isolation squeezing, in addition to the selective cementation furnished by the use of a stage tool. The petroliferous section is naturally considerably thinner on the east, north, and west (edge water), as well as on the south, in which direction the controlling West Guara fault cuts the wells deeper and deeper. Common practice has called for an isolation squeeze at the top of the petroliferous section in each well.

Excepting the uppermost Oficina formation sand, the Theta, all of the upper

sands (Oficina-1 to Oficina-13) down through the C sand contain light-gravity (35°–57° API) wax-oil. One of these, the Oficina-11, produces up to 57° API oil (average gas-oil ratio, about 700), which is the lightest-gravity dark oil in the entire Greater Oficina area and probably in all of Venezuela. Some higher gravities are known, but all of these are from condensate or very high gas-oil ratio wells. The remaining producing sands from the C through the N contain non-waxy oil, some with gravities as high as 44° API. There is a very marked trend of decrease in gravity with depth in the section in this particular field and the lowermost sands below the N are too heavy to be of commercial importance at present. The section on Fluids contains a detailed chart showing decrease in gravity with depth in a single reservoir, the M_u sand.

After the major lower sands (D_3, D_4, F_7, H, and M_u) were fairly well drilled a program of interspaced wells (256 meters) was started for exploitation of the shallow sands, none of which was being drained. These wells are usually drilled just through the C sand (± 5,400 feet) and many triple-zone 25–30-day completions are being made.

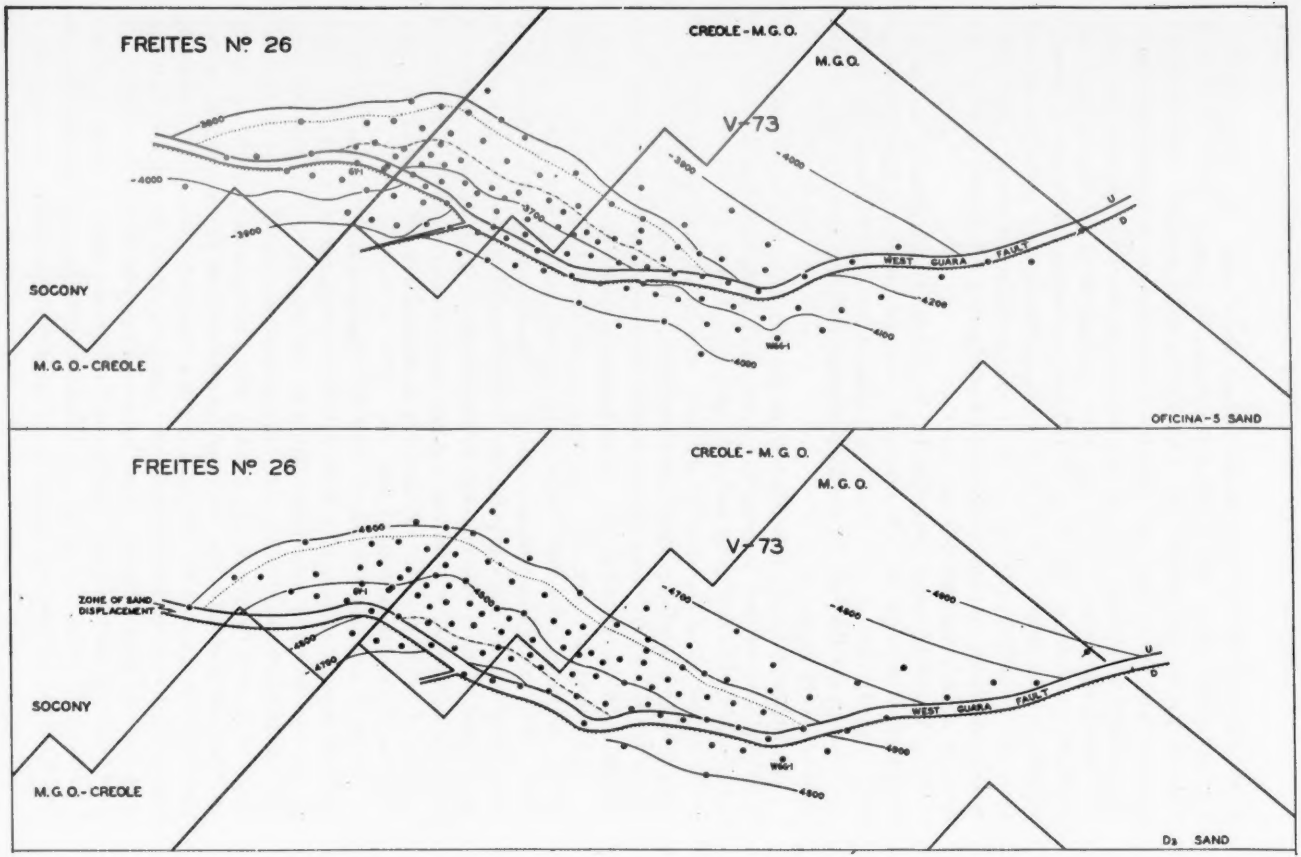
A number of the thick blanket sands are extremely well sorted and many individual samples show permeabilities as high as 10,000 millidarcys. These permeabilities are the best in the entire Greater Oficina area.

As almost all of the sands in the field have initial gas caps, production is mainly by combination gas-cap and solution drive. It is not yet known whether any of the sands have water drives effective at present rates of withdrawal. Two sands, the Oficina-11 and the N_u, are undersaturated with gas.

East Guara field (Fig. 16).—Thirty-seven wells (17 GG, 19 GS, and 1 GM) have been drilled in this field, resulting in 33 producers, 1 potential pumper, and 3 dry holes. The field, as now outlined, is 10 kilometers long and less than a kilometer wide excepting at one point. The 7 structural segments and 35 productive sands yield 76 reservoirs. This field is second only to West Guara in richness in that the 1,830 surface acres and 239,862 productive acre-feet give an over-all average of 125 feet of net oil sand per acre. Production to January 1, 1946, amounts to about 6.5 million barrels.

The most exceptional features of the East Guara field are the comparatively steep (as high as 16°) dips locally present, the development of small domes in two of the segments, and some block tilting so that segment dip is in places much different from regional dip. The steep dips concentrate most of the oil in relatively small areas, and 256-meter grid is being drilled in these particularly rich spots; as in West Guara, sands are alternated between wells on the 14-acre grid, so that final drainage per sand will be about 40 acres. Also as in West Guara, extremely long petroliferous sections (as much as 2,900 feet) are locally present, so that a stage tool and several isolation squeezes are necessary in most of the wells.

To date, producing sands range from the Oficina-1 sand near the top of the Oficina formation down through the T sand near the base of the formation. No wax-oil sands have been encountered, and most of the sands produce oil within a


FREITES Nº 26
CREOLE - M.G.O.
M.G.O.
V-73
-3800
-4000
-3900
-3700
-4200
-4100
-4000
WEST GUARA FAULT
U
D
SOCONY
M.G.O. - CREOLE
OFICINA - 5 SAND
FREITES Nº 26
CREOLE - M.G.O.
M.G.O.
V-73
-4600
-4700
-4800
-4500
-4900
ZONE OF SAND DISPLACEMENT
WEST GUARA FAULT
U
D
SOCONY
M.G.O. - CREOLE
D3 SAND

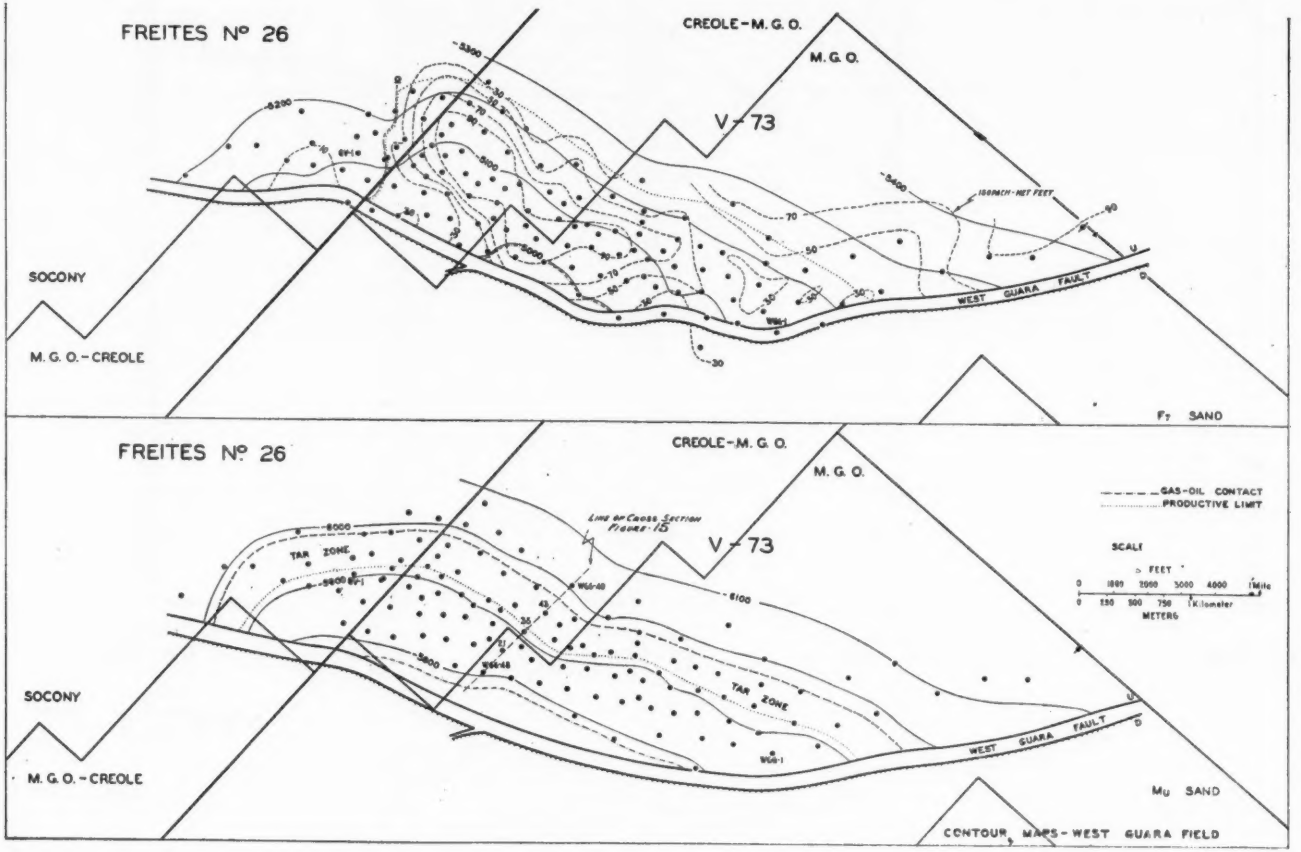
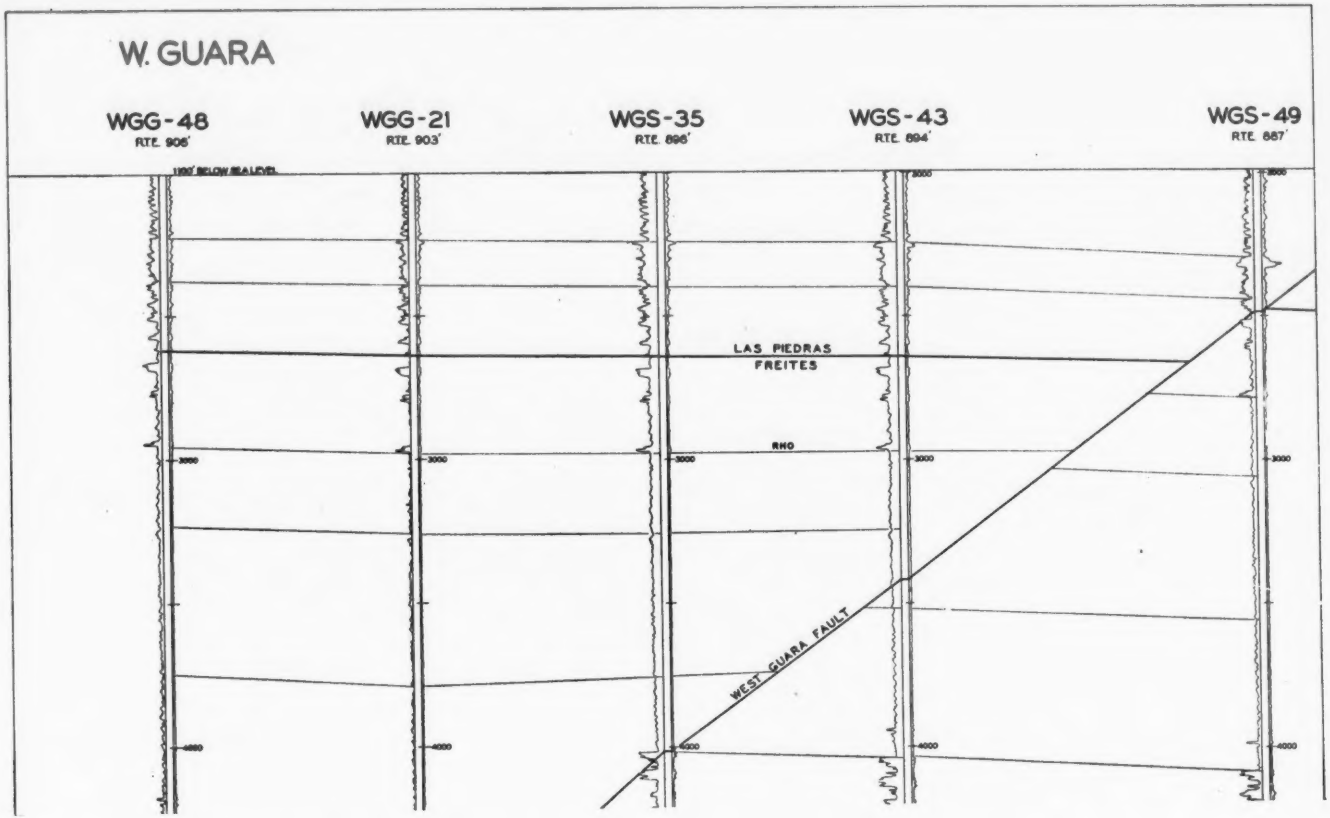


FIG. 14.—Contour maps, West Guara field.


W. GUARA
WGG-48
RTE. 906'
WGG-21
RTE. 903'
WGS-35
RTE. 898'
WGS-43
RTE. 894'
WGS-49
RTE. 887'
LAS PIEDRAS
FREITES
RHO
WEST GUARA FAULT
3000
4000

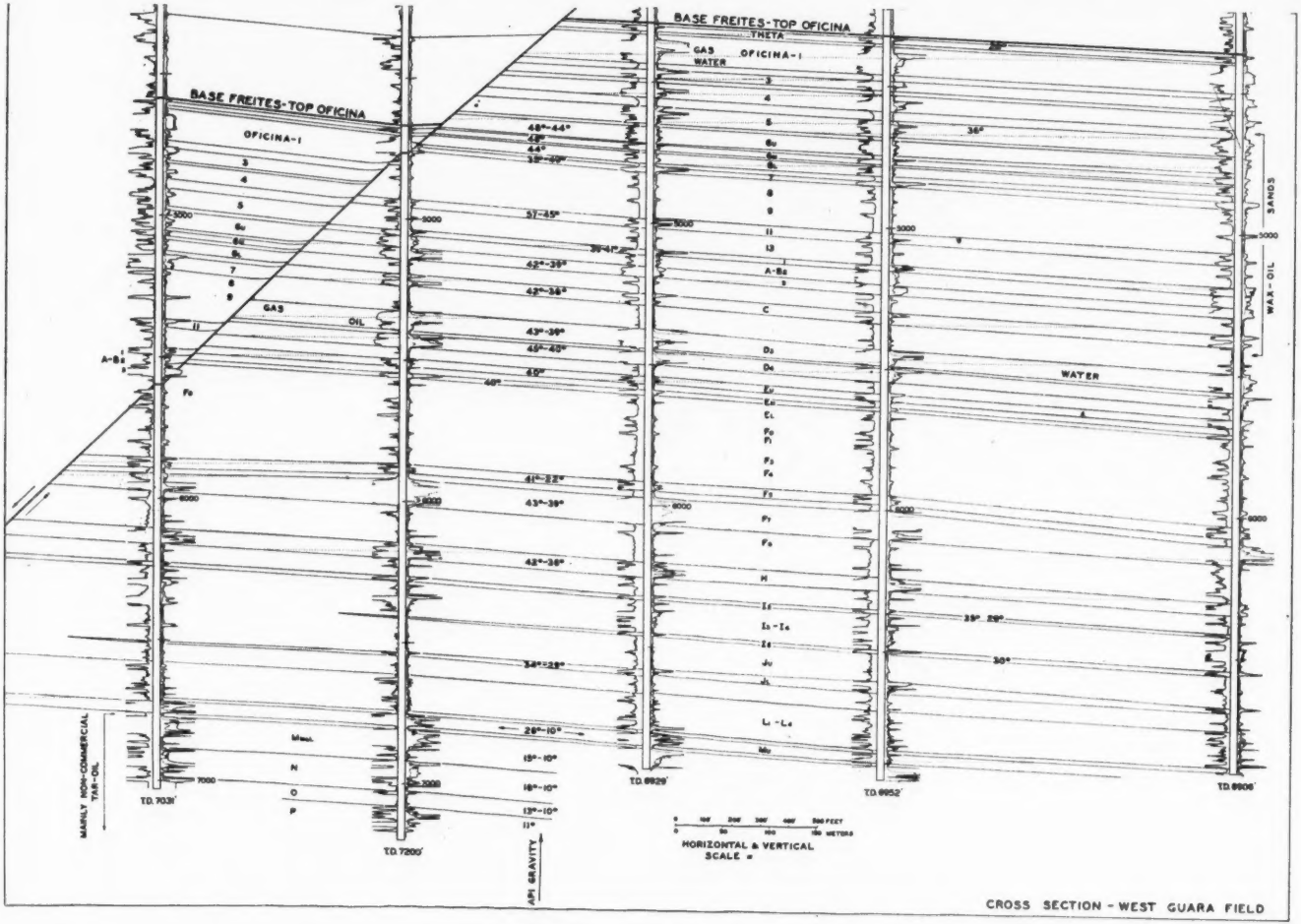
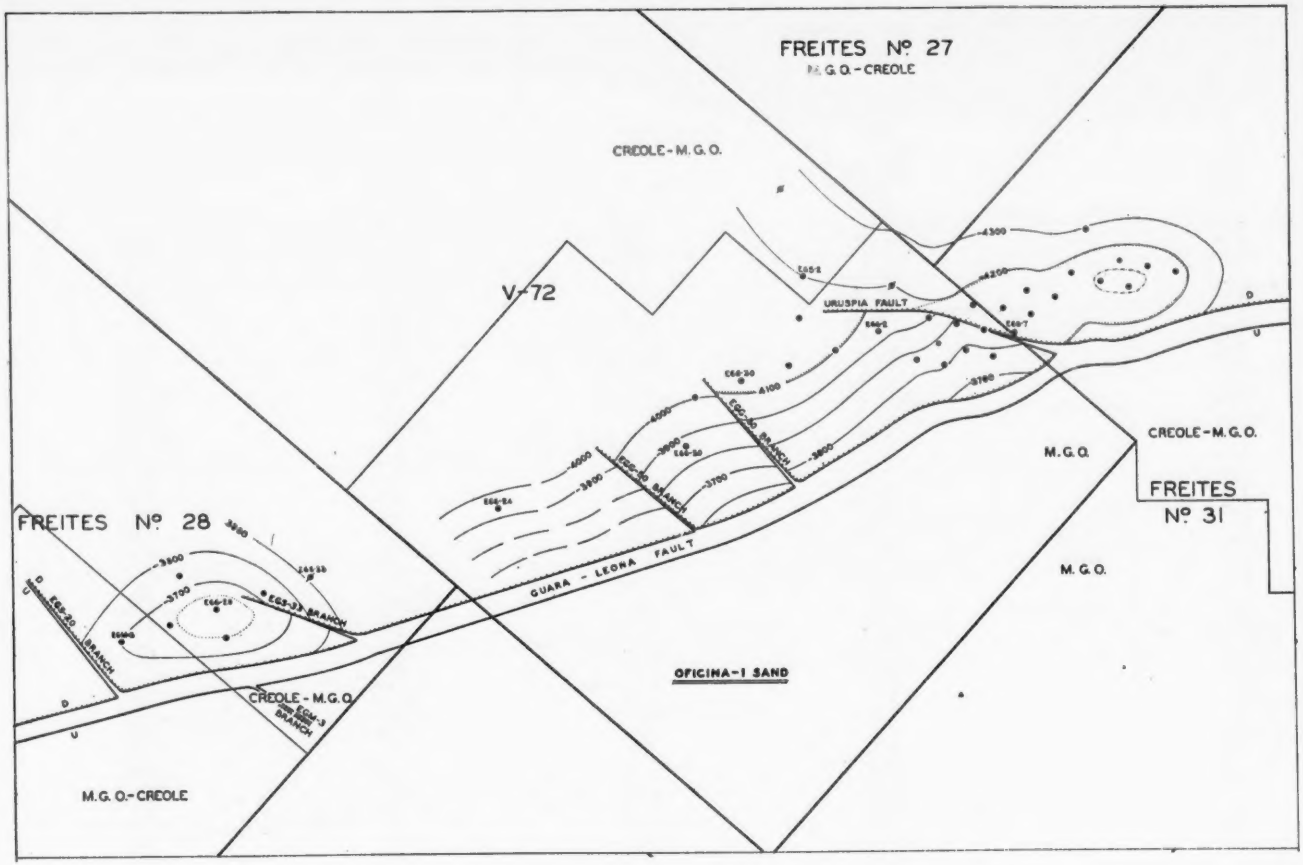


FIG. 15.—Cross section, West Guara field.


FREITES Nº 27
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V-72
URUSPIA FAULT
CREOLE-M.G.O.
M.G.O.
FREITES
Nº 31
M.G.O.
FREITES Nº 28
GUARA - LEONA FAULT
OFICINA-I SAND
CREOLE - M.G.O.
M.G.O.-CREOLE

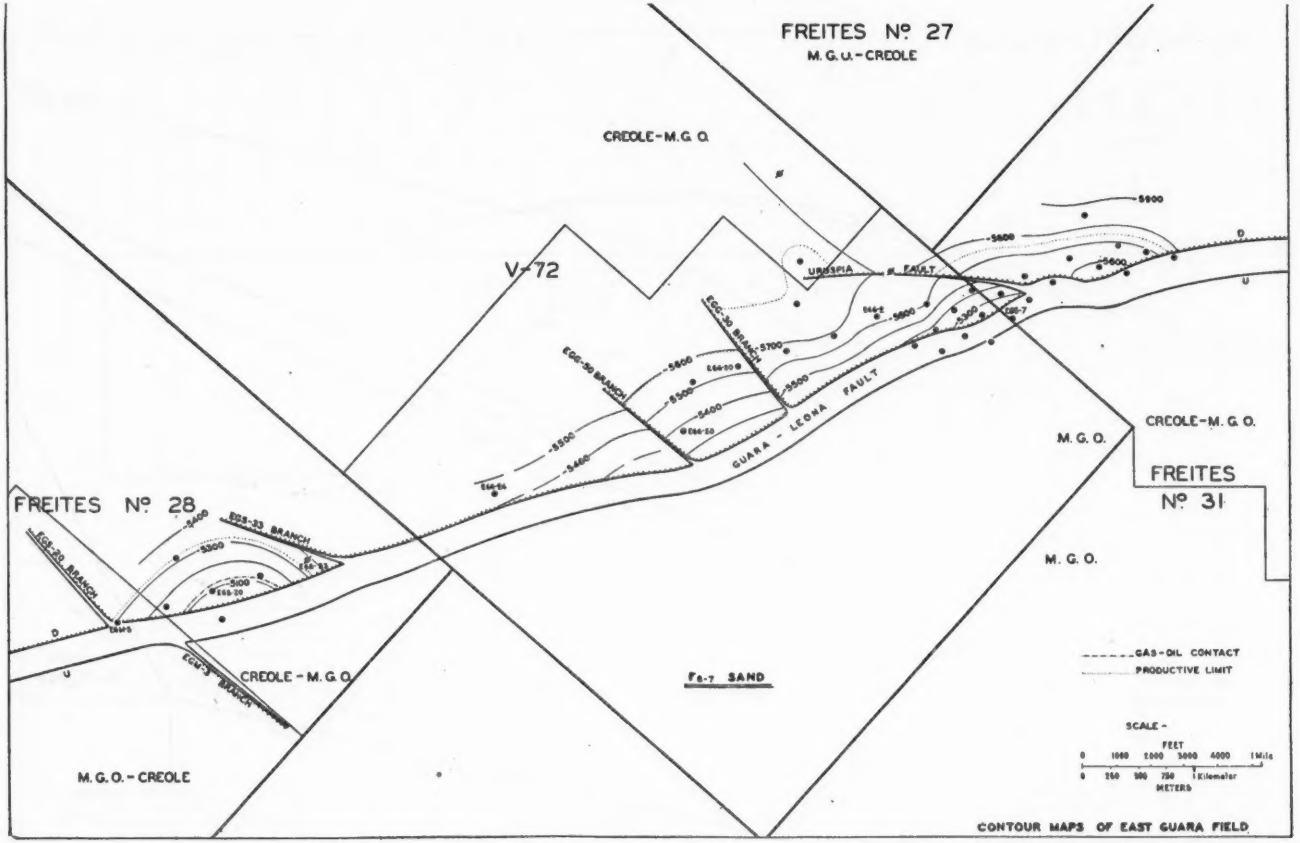


FIG. 16.—Contour maps, East Guara field.

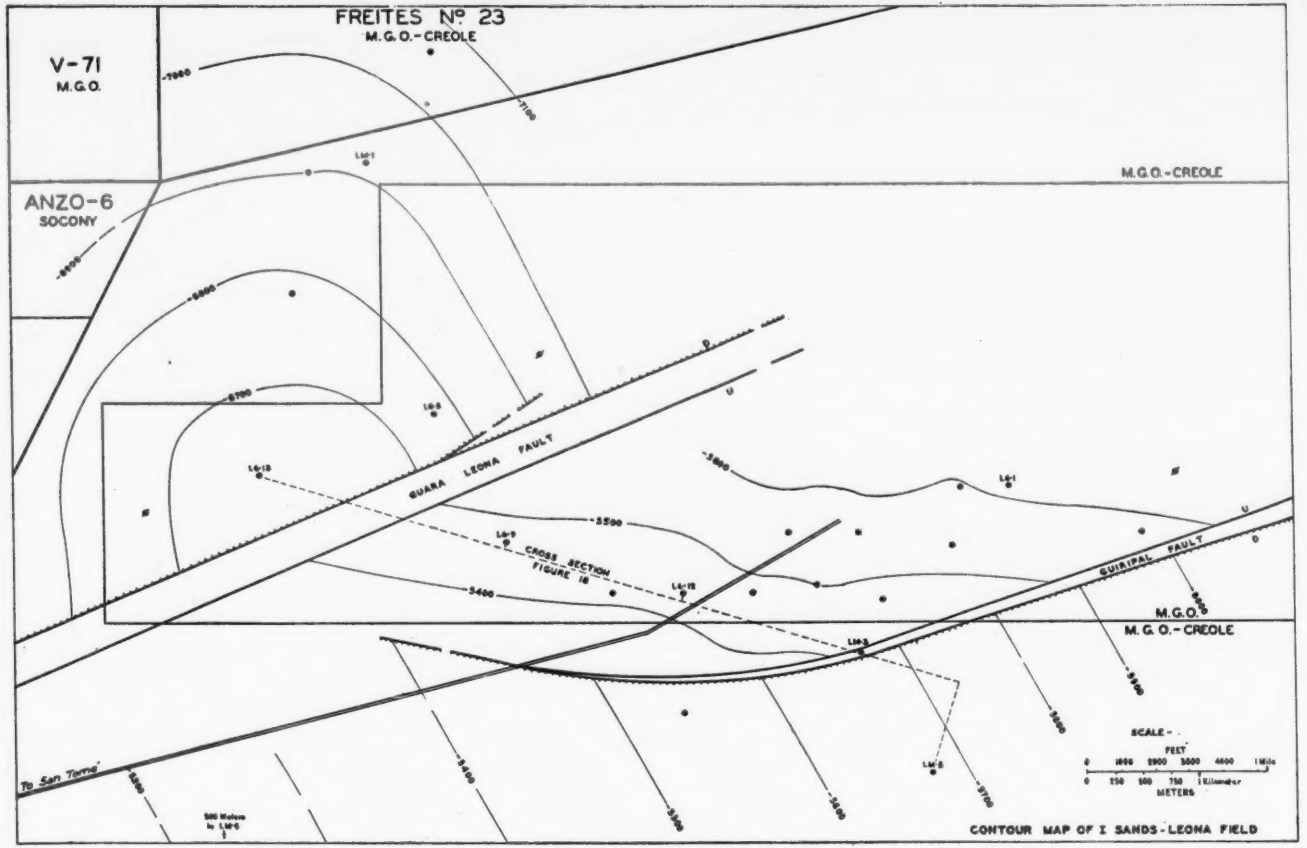


FIG. 17.—Contour map of I sands. Leona field.

gravity range of 25°–31° API; extremes in production gravities are 37° and 16° API. Figure 16 includes structural maps on the Oficina-1 and F_{6-7} sands. The structure of the field is considerably more complex than drawn, because shortened sections indicate the presence of a number of small faults, and accumulation indicates unidentified faulting south of the Guara-Leona fault.

It is remarkable that so little section is disturbed by the 600–1,000-foot displacement of the Guara-Leona fault; as with all of the smaller faults, it is usually possible to correlate sections both above and below the fault to within several feet of the actual displacement. The East Guara field is exceptional in that it contains one branch fault, the Uruspia, which in part has a dip of $\pm 70°$; this is the only known fault with a dip of more than 50° in the entire Greater Oficina area.

The bottom-hole samples have so far shown that none of the East Guara sands is undersaturated with gas, although very few gas caps have been encountered. It is probable that most of the reservoirs are under combination solution and gas-cap drive, and it is possible that water drives may be present. Actually, very few data are available on the type of drives in this field.

LEONA DISTRICT

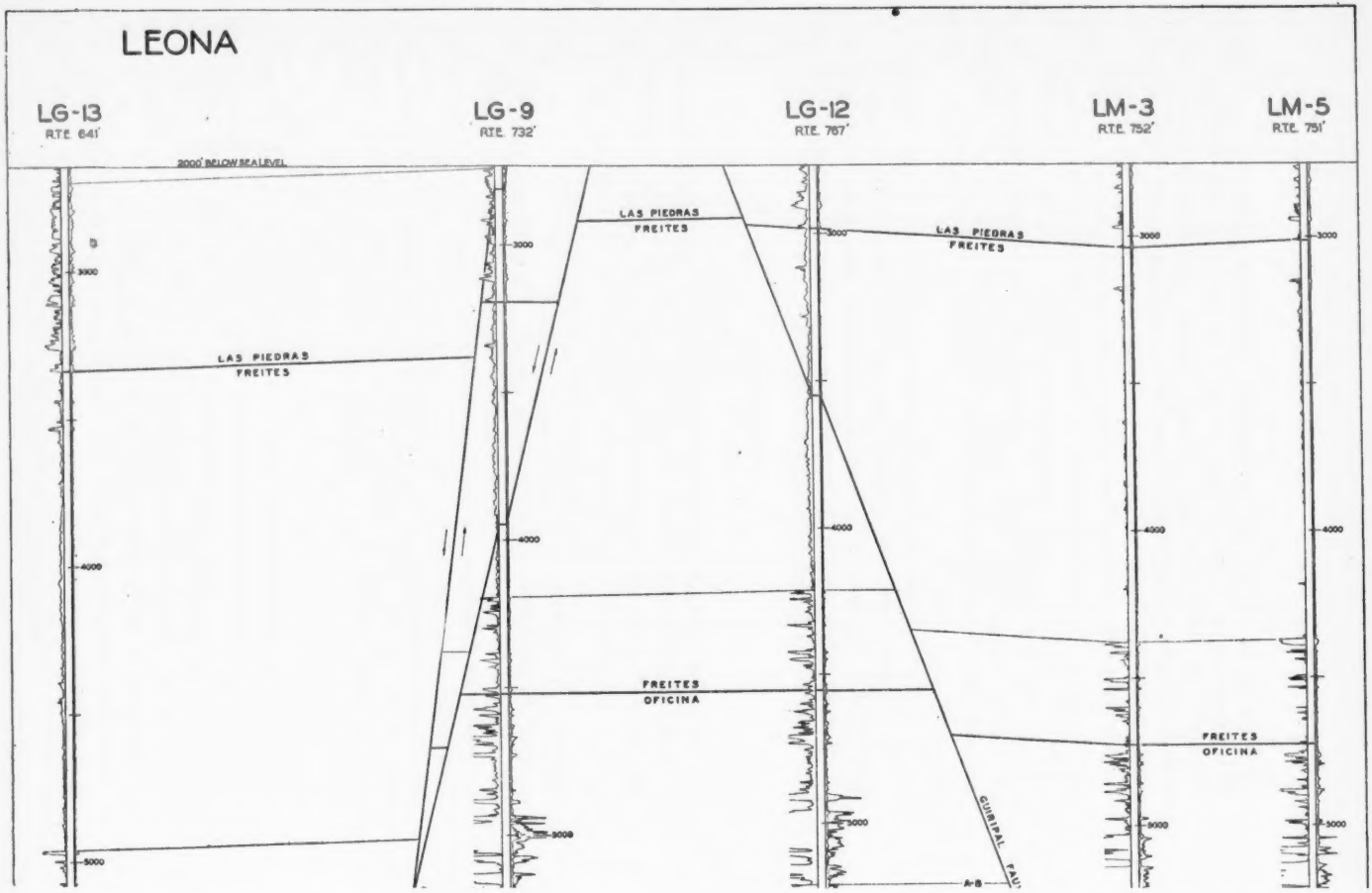
Figs. 17 and 18

Twenty-five wells (17 LG and 8 LM) have been drilled in the three productive segments of the Leona district. Twenty-one of these wells were completed as producers, one was a producer abandoned because of mechanical trouble, and three others were abandoned dry holes. Only one of the five wildcat wells in the district has been a dry hole. After producing about $3\frac{1}{2}$ million barrels of oil, 16 wells are still producing satisfactorily and 5 are dead.

Wells in the Leona district actually contain a larger percentage (± 40 per cent) of sandstone in the Oficina formation than do wells in any other district, but good fault traps have not yet been encountered. Production is limited to thin sands which almost invariably pinch out toward the west, thus giving the necessary closure in this direction. The very thick blanket sands do not pinch out and therefore do not meet all requirements for accumulation in this particular area.

In the Leona district, the 5,310 surface acres and 127,734 productive acre-feet furnish an over-all average of only 24 feet of net sand per acre. This is unfavorably comparable with the 49 feet of net sand per acre in the Oficina district and is extremely poor when compared with the 155 feet, and 125 feet of net sand per acre in West Guara and East Guara, respectively. These factors, coupled with the fact that the uppermost known oil sand is below 6,000 feet, have temporarily stopped exploitation drilling. Present spacing averages only 1 well to 253 surface acres. The thin sands have been producing remarkably well and the wide spacing is undoubtedly a major factor in the continued production.

Following completion of Tigre No. 2 (later renamed LG-1) in 1937, no additional drilling was carried on until 1940 when LM-1 and LG-2 were spudded.


LEONA
LG-13
R.T.E. 641'
LG-9
R.T.E. 732'
LG-12
R.T.E. 767'
LM-3
R.T.E. 752'
LM-5
R.T.E. 751'
2000' BELOW SEA LEVEL
LAS PIEDRAS
FREITES
FREITES
OFICINA
GUARIPAL FAULT
A-B
3000
4000
5000

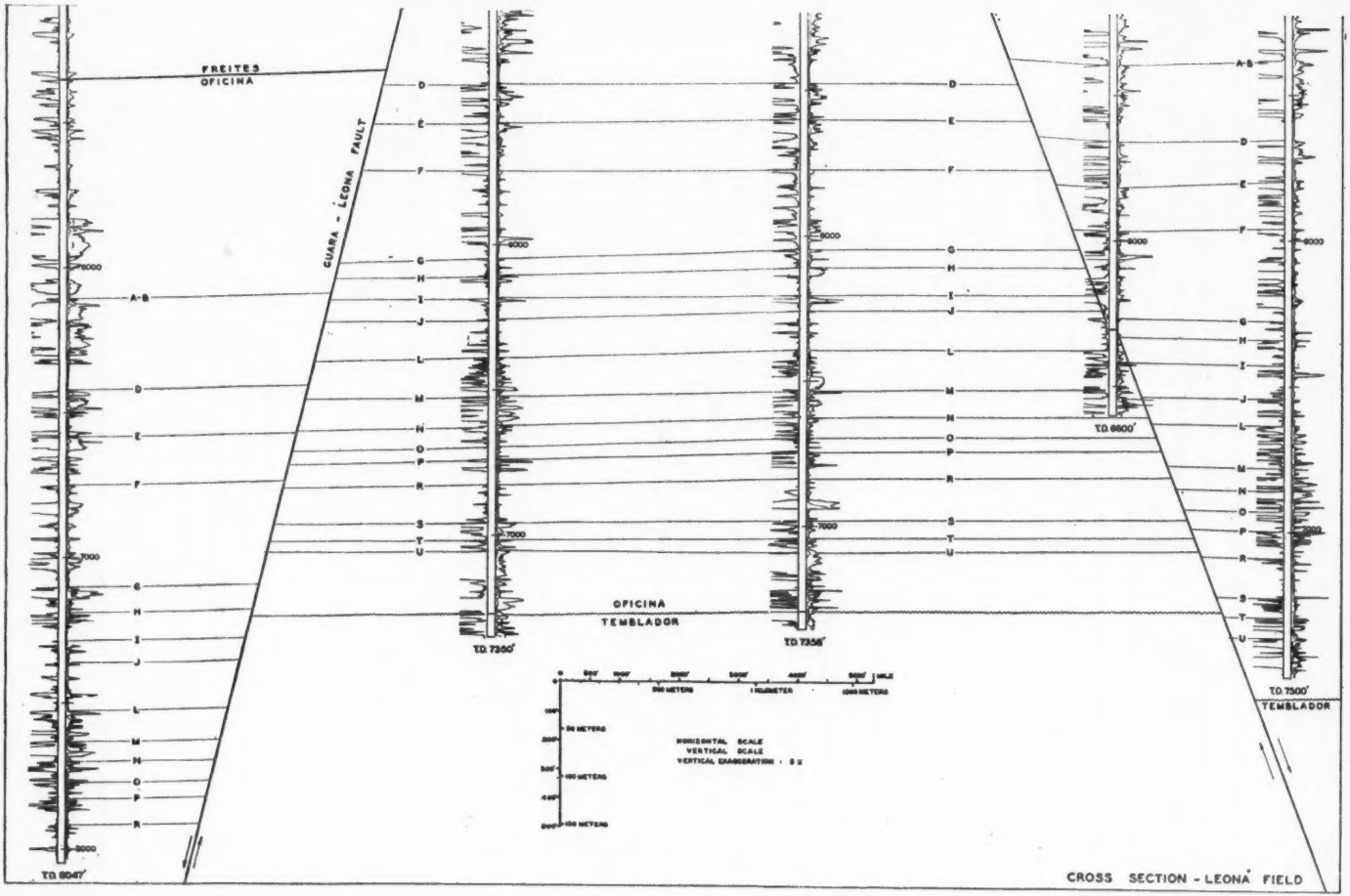


FIG. 18.—Cross section. Leona field.

Shortly after LM-1 was completed, a drilling campaign with 3–5 rigs was initiated. After continued lack of success in finding a prolific producing area, drilling in the district stopped, following the junking of LG-17 in December, 1942. Eventually, additional wells will be drilled here.

LG-1 was based on refraction-seismograph work, LM-1 largely on surface geology, and the remainder of the wells mainly on reflection seismograph and subsurface geology. Very little structure drilling has been done, mainly because reliable and persistent beds were below the depth capacity of the drills available prior to the last several years.

Structurally the Leona field is a horst with accumulation present on both sides of the two faults forming the horst. In other words, accumulation has been encountered both north and south of the horst as well as within the horst. As far as now known, most of the accumulation is under structural-stratigraphic control; this is especially true in Central Leona where all productive sands pinch out westward.

The large Guara-Leona fault has been discussed in the preceding paragraphs on the Guara district. In the Leona field, the displacement amounts to about 1,400 feet at J sand depths, and displacement is increasing eastward beyond the limits of present information. The constant gradual thickening on the north downthrown side of the fault is best developed in Leona and this thickening in known relatively flat beds implies continual subsidence along the fault during Oficina, Freites, and a part of Las Piedras sedimentation. The Guiripal fault, which is on the south upthrown side of the Guara-Leona fault, is downthrown on the south and also shows a markedly increasing displacement toward the east. On the west, this fault may die out before reaching the Guara-Leona fault—at least the displacement is decreasing in a short distance.

LG-1, in Central Leona, encountered the top of the Temblador formation at about 7,400 feet, and was drilled 400 feet into the formation. Most of the wells in this district have been stopped a considerable distance above the Temblador and no wells have reached basement.

In the Leona district, the top accumulation is in the F sands, but the uppermost oil is produced from the G sand. The G through J part of the section contains practically all of the important sands; in fact, the I sand group alone is the source of about 80 per cent of production to date. Production gravity for the field averages about 29° API. Gravities range from 15° to 40°, but most of the produc- is between 25° and 35° API. No wax-oil has been encountered.

Figure 17 is a structural map based on the important I sand group. Figure 18 presents an electrical-log section across the two important faults and clearly illustrates the stratigraphic thickening on the downthrown side of the Guara-Leona fault.

North Leona.—Of the 8 wells drilled on the north downthrown side of the Guara-Leona fault, 6 are producers, 1 is a producer abandoned for mechanical reasons, and 1 is a dry hole. Structural closure is apparently caused by truncation

of a basinward-plunging nose by the Guara-Leona fault. The uppermost oil sand, the G, is at 7,100 feet in this segment.

Central Leona.—Thirteen wells, one of which is a dry hole, have been drilled in the central segment between the Guara-Leona and Guiripal faults. Accumulation is controlled by north dip, the Guiripal fault on the south and pinch-outs of all productive sands on the west. The uppermost oil sand, the G sand, is at 6,000 feet in this segment.

South Leona.—Three wells have been drilled south of the Guiripal fault: two were poor completions in a 15° API I sand and one was a dry hole. Accumulation is apparently controlled by westward pinch-outs.

MEREY DISTRICT

(Figs. 2 and 10)

The main structural feature of the Merey district is the long Merey fault which is downthrown basinward and generally parallels the Guara-Leona fault. Relatively little is known about this district, excepting that nothing lighter than 19° oil has been encountered in the 3 completions out of 5 wells drilled. The heavy oil has discouraged development, although it is certain that numerous wells will be drilled in this relatively shallow area (3,700–5,000 feet) in the future. Basement was reached at 6,036 feet in Merey No. 2.

PANDO DISTRICT

(Fig. 2)

This district, which is south of the Leona district and east of the Merey district, has no economic importance at present, because the only wells drilled, Tigre No. 1 and Pando No. 1, were dry holes. Exploration with the reflection seismograph and the structure drill has covered only a very small part of the district. Basement was encountered in Tigre No. 1 at 6,421 feet.

NIPA DISTRICT

Only one well, NG-1, has been drilled in this district, which is immediately north of the Guara district. The controlling feature is the long east-west Laysme, fault which is downthrown on the south. This fault is very similar to the West Guara fault. The first well contains only one productive sand, the G sand at 7,100 feet, which suggests that an updip pinch-out is partly the cause for accumulation. Two rigs are now drilling in this district, one a Socony offset west of NG-1 and the other at NG-2, a wildcat 9 kilometers due east of NG-1. The major part of the district has been covered by the reflection seismograph and is now being checked with the structure drill.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 31, NO. 12 (DECEMBER, 1947), PP. 2170-2192, 12 FIGS.

OIL FIELDS OF WEST BUCHIVACOA, VENEZUELA[1]

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ABSTRACT

Before 1907 attention was directed to the oil possibilities of West Buchivacoa by a fairly big and active seepage of light oil at El Mene.

The first known geological report on the El Mene area was made in 1912 when the region was uninhabited. Drilling commenced in 1920. By 1925 the peak of production was reached. Production still continues, a total of 29 million barrels of oil having been obtained.

The presence of oil at El Mene is due to a late movement which rejuvenated anticlinal folding on a pre-existing eroded axis. An important contributing factor is that the overburden of early Miocene rocks has curbed the folding movement, thus preventing excessive shattering which would have resulted in the escape of most of the oil. Farther along the axis, crushing and shattering has taken place, and remnants of oil in fault traps are all that have been formed, for example, 3 million barrels at Media and 4 million barrels at Hombre Pintado.

The process of erosion is impressively displayed in the semi-arid zone of the first foothills, where extremely heavy showers of short duration remove the generally soft sandy rocks with great rapidity.

Drilling at El Mene was very easy and the average depth of wells was 1,000 feet. Producing-sand thicknesses are variable but average 25 feet. The oil is of mixed base, sulphur-free and of gravity 32°API (.865).

INTRODUCTION

The Bernabé Planas Concession over the District of Buchivacoa was granted in 1907. Its area is approximately 2,600 square miles. It was originally taken up on account of a big seepage of oil at El Mene.

The first known geological investigation of the oil possibilities of the area was made by E. H. Cunningham Craig and the writer in 1912. The anticlinal structure and the oil seepage were encouraging signs. Craig made two locations at El Mene at that time which were drilled many years later and produced between them over 600,000 barrels of oil.

The Concession was acquired by British Controlled Oilfields, Ltd., on January 5, 1920, and the first well in El Mene was completed in September that year. The success of the El Mene field, however, started in March, 1923, with Well No. 15 (one of the locations chosen by Cunningham Craig 11 years previously).

The territory was subsequently divided as follows.

	Square Miles		
	British Controlled Oilfields, Ltd.	*Central Area Exploitation Co. (Venezuela) Ltd.*	*Standard Oil Company of Venezuela*
1920	2,600	—	—
1924	1,700	—	900
1926	1,100	600	900
1931	1,400	—	1,200

[1] Manuscript received, January 25, 1947.

[2] Trinidad Petroleum Development Company, Ltd. The writer is indebted to British Controlled Oilfields, Limited, for permission to submit the accompanying information, which deals with the B.C.O. 1,400 square miles, or roughly the western half of Buchivacoa. The geological information given is based on several years' work of various British geologists, T. O. Bosworth, L. Owen, H. G. Busk, D. Wood, C. C. Wilson, R. M. S. Owen and others and American and European paleontologists including H. D. Hedberg, Floyd Hodson, J. Dufour, N. M. Bramlette, W. S. Hoffmeister, R. E Koch, and R. Bullen Newton.

GEOGRAPHY

The position of Buchivacoa in Venezuela is shown in Figure 1. It consists of three main parts (Fig. 2): (1) a low coastal plain; (2) a belt of low mountains up to 2,500 feet altitude; and (3) the southern mountainous region with altitudes up to a maximum of 7,000 feet.

The climate is directly dependent on the topography. The northern plains receive little rainfall. Vegetation is sparse and consists mainly of cactus and a type of wild pineapple and a few thorn bushes. Desert phenomena, such as sand storms and mirages are common, and shifting sand dunes are prevalent near the sea shore.

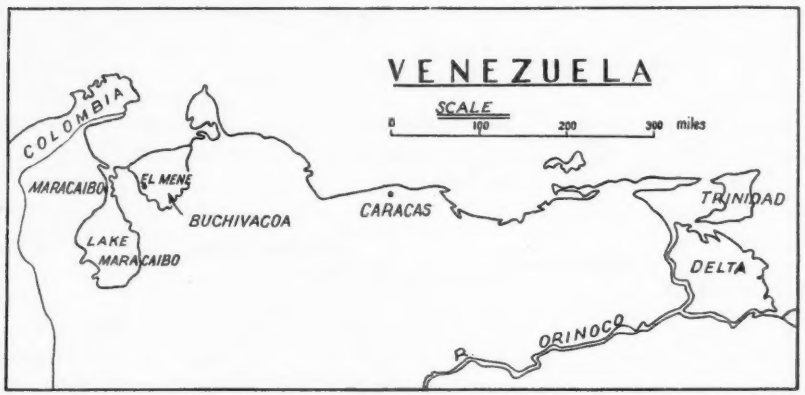


FIG. 1

In the intermediate area the trade winds from the northeast begin to drop moisture more freely and the vegetation, while still of a semi-arid nature, begins to grade into a more normal tropical type. Rainfall averages 40½ inches (18 years' average) in El Mene, but is characterized by falling mostly in excessively heavy showers of short duration. The result is that erosion is extremely high, and often causes severe damage to roads, bridges, *et cetera*. Many foundations of structures on fairly level surfaces, which were at ground level in 1928, are now 1–4 feet above ground. Many road drains have developed into stream beds 30 feet wide and 10 feet deep in the same period. In fact the natural process of erosion is so exaggerated in this region that much change in topography is apparent in the span of a single lifetime.

In the southern area, with its mountains rising to 7,000 feet in the Fila de las Pavas, there is full tropical climate and vegetation. The southern side of the Fila de las Pavas Range, which forms the boundary between the Buchivacoa district of the state of Falcon, and the state of Lara, drops one mile with great steepness.

With this drop there is a remarkable and sudden climatic change to semi-arid conditions again, which gradually become normal tropical farther south.

PHYSIOGRAPHY

The general grain of the country is west-southwest-east-northeast in conformity with the general geological trend of the state of Falcon. Drainage is consist-

FIG. 2

ently northward, the rivers cutting through the ranges at right angles, where faults or easily weathered beds occur.

The rivers do not exceed about 80 miles in length and all become dry during the dry season.

Buchivacoa does not offer much scope for agriculture. Most of it is uninhabited, the rains are too heavy, and the ground is too scorched by the sun for long periods. In the south, where climatic conditions are better, the country is too mountainous and too lacking in means of communication. The permanent water in the upper reaches of the rivers is not sufficient for irrigation.

AREAL GEOLOGY

The geology of West Buchivacoa falls into three well defined units: (1) the Northern Plains (550 square miles), (2) the Barranca Basin (200 square miles), (3) the Southern Mountainous area (650 square miles).

The Northern Plains consist of alluvium which gives no clue to underlying structure.

The Barranca Basin is the most notable tectonic unit of the whole region. It is in the shape of a flat saucer, 16 miles in diameter, and filled with alluvium. It has provided a rigid barrier against which rocks have folded and crumpled on three sides.

Against the northern edge of the Barranca Basin is the El Mene fold axis which continues east-northeast for 100 miles. Toward the west it pitches down under alluvium, but farther west brings Eocene rocks to the surface slightly *en échelon.*

South of the Barranca Basin the underlying Miocene beds emerge in the form of a rim of beautiful dip slopes and scarps, and field mapping by British Controlled Oilfields geologists in the highest mountains of Buchivacoa which rise to 7,000 feet altitude has revealed steeply dipping and highly disturbed beds, interpreted in some cases as overthrusts with nappes which have ridden forward as much as 10 miles.

SURFACE INDICATIONS OF OIL AND GAS

The biggest seepage of West Buchivacoa is at El Mene, and must have been known for centuries. "Mene" is an Indian word meaning oil. It occurs at the northeastern edge of the producing field, close to the Agua Clara rocks which protrude through the overlying La Puertas. No other oil seepage has been found in or near the El Mene field.

Two small seepages of oil occur at Media, 4 miles east-northeast (air line) from El Mene, both being where Eocene is faulted against younger beds. These seepages gave rise to the theory that oil might be trapped in younger beds down the flank and therefore drilling was undertaken.

Several seepages of oil occur at Hombre Pintado, 10 miles (air line) east-northeast from El Mene.

There are fairly extensive seepages of oil and pitch at Quiros on the westward continuation of the Vega Oscura anticline, but they are just outside Buchivacoa. South of Vega Oscura various small seepages of oil occur for several miles along the junction where Agua Clara beds lie with angular unconformity on the Eocene.

STRATIGRAPHY, REGIONAL

The beds at the surface and penetrated in wells range from Recent to Eocene. The total thickness measured in southwestern Buchivacoa amounts to 16,500

feet. They consist entirely of marine and brackish-water deposits, with evidence of desert or at least arid conditions in Pleistocene time. The main characteristic of the sediments is rapid change of type and of thickness, and non-sequence; in fact, lateral variation is exhibited to a marked degree.

STRATIGRAPHY—INDIVIDUAL FORMATIONS

RECENT

Recent formations include sand dunes on the North Coast, mud flats and alluvium, and boulder terraces up to 2,493 feet elevation.

PLIOCENE-MIOCENE—LA PUERTA FORMATION (4,500 FEET)

In the El Mene region the formation consists of an upper part, possibly Pleistocene, mainly of mottled clays. The lower part comprises loosely consolidated sand and pebble beds with pebbles exhibiting what may be wind polishing. These pass downward into massive micaceous highly ferruginous bands. Below these are lignites and gray clays and sands and finally 500 feet of mottled clay. Fossils are rare throughout. The whole formation appears to be lacustrine and brackish-water in origin.

MIOCENE—CERRO PELADO FORMATION (2,500 FEET)

The type section of Cerro Pelado is near Coro more than 100 miles from southwest Buchivacoa. There is little in common between the beds of this formation in the two areas except age. In southwest Buchivacoa it consists of sands, conglomerates, shales, and thin limestones, indicating various marine incursions into brackish-water conditions. An exceptional constituent is detrital coal, formed of the debris of lignitic coal redeposited in strata up to a few inches thick.

LOWER MIOCENE-OLIGOCENE—AGUA CLARA-SAN LUIS (6,000 FEET)

In this case also the type section is more than 100 miles away and is no guide to the lithologic character of the beds in southwest Buchivacoa. This formation represents an essentially marine phase which gave rise to dark fossiliferous shales and thin limestones and sandstones. Some beds of lignitic coal are present. In a Vega Oscura well 1,300 feet of mottled clay were found at the base of this formation but this clay has not been recognized cropping out anywhere in the vicinity. Normally the basal beds consist of calcareous sandstones.

EOCENE: MORE THAN 3,000 FEET

In the mountainous part of West Buchivacoa, about 300 square miles of the surface consists of Eocene rocks. They are so greatly disturbed that no reliable measurement of thickness can be made. The rocks exposed consist of an upper sandy phase, an intermediate and fairly thick group of blackish shales (Turpure shales) and lowermost quartzites (Mojino quartzites).

CORRELATION

Correlation has been based mostly on paleontological evidence. Locally, however, lithological characteristics have proved very useful in field mapping. For instance, the presence of detrital coal and angular feldspars in the Cerro Pelado, and their absence in the underlying Agua Clara, give a clear definition of the junction between these two formations in the field locally.

STRUCTURE

The main folding movements of West Buchivacoa, as of the whole of the state of Falcon, are subsidiary to the Venezuelan Andean uplift, with which they are parallel. Movement has been very severe and very frequent and has left highly compressed folds, faults, and thrusts. The fact that movement and deposition have been contemporaneous has resulted in great variability of deposits during the same time range.

The tectonics of the western side of Buchivacoa are extremely complicated as three systems of folding meet there: the dominant structures are west-southwest-east-northeast on the Falcon trend. Superimposed on this are north-northwest-south-southeast influences of the east side of Lake Maracaibo. Finally the east-west trend of Toas Island overlaps and merges into the Falcon trend.

The principal structures of West Buchivacoa are from north to south as follows.

1. The Mayal-La Guinea uplift. This uplift, discovered by torsion balance in 1930, brings an Eocene mass within 300 feet of the alluvial plain beneath which it lies (Fig. 3). Its trend is east-west, and it is strongly asymmetrical, with the steep limb on the south. Indications are that this uplift is anticlinal,but the three wells drilled into it are not sufficient to prove this.

2. The El Mene fold axis is the northernmost expression visible at the surface in that vicinity of the intense movement which has affected Falcon (Fig. 4). At El Mene the fold takes the form of an asymmetrical anticline, with the steep limb on the north. Most of this limb has been cut off by a strike fault downthrowing 4,000–5,000 feet toward the north. This fold axis continues eastward through the small oil fields of Media and Hombre Pintado to Coro 120 miles away (Fig. 12).

3. The rigid Barranca basin has already been mentioned. A number of strong folds run into its eastern rim radially, where they are immediately ironed out.

4. The Vega Oscura anticline is a Falcon trend structure whose north flank is the southern part of the Barranca Basin. Its eastern continuation is obliterated by Alpine type structures.

5. The southeast area comprises the highest mountains, up to 7,000 feet altitude, and as already mentioned the most complicated structures.

The three main structures of West Buchivacoa have all been tested well into the Eocene, but the Cretaceous was not reached anywhere.

Structure	*Depth drilled into Eocene (Feet)*	*Stratigraphic Position of Eocene*	*Indications of oil in Eocene*
La Guinea	3,541	Lower Pauji or Upper Misoa-Trujillo	None
El Mene	1,518	Upper Middle or Upper Eocene	Various oil showings in cores and indications by Schlumberger
Vega Oscura	1,261	Pauji shale	None

The Media field, 4 miles east-northeast from El Mene, is situated entirely in the alluvium of the Northern Plains, just north of the first hills and also just north of the major strike fault, which downdrops the northern flank of the El Mene anticline.

Hombre Pintado is 10 miles (air line) east-northeast from El Mene, among the first foothills which emerge from the Northern Plains. It is also north of the big

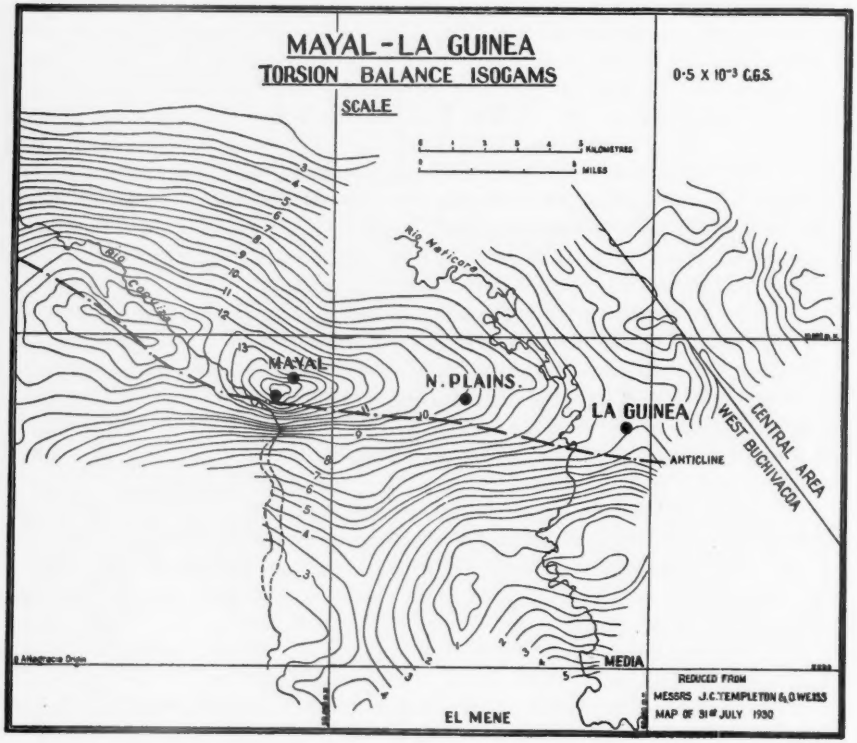


FIG. 3

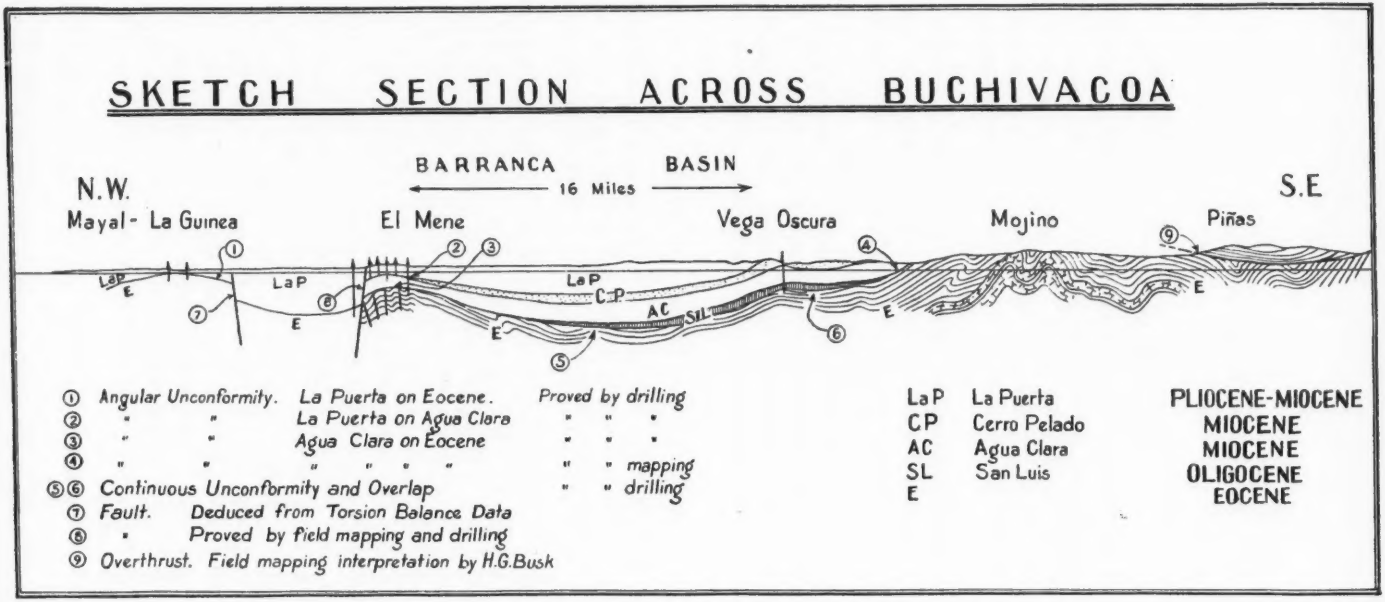

SKETCH SECTION ACROSS BUCHIVACOA
BARRANCA BASIN
16 Miles
N.W.
S.E
Mayal - La Guinea
El Mene
Vega Oscura
Mojino
Piñas
LaP
CP
AC
SL
E
① Angular Unconformity. La Puerta on Eocene. Proved by drilling
② " " La Puerta on Agua Clara " " "
③ " " Agua Clara on Eocene " " "
④ " " " " " " " " mapping
⑤⑥ Continuous Unconformity and Overlap " " drilling
⑦ Fault. Deduced from Torsion Balance Data
⑧ " Proved by field mapping and drilling
⑨ Overthrust. Field mapping interpretation by H.G.Busk
LaP La Puerta PLIOCENE-MIOCENE
CP Cerro Pelado MIOCENE
AC Agua Clara MIOCENE
SL San Luis OLIGOCENE
E EOCENE

FIG. 4

El Mene-Hombre Pintado strike fault. The surface rock exposures afford similar evidence to the subsurface information obtained from the Media wells, namely, that they are both in a zone of highly compressed and faulted strata.

STRUCTURE—SUBSURFACE

Surface geology amply demonstrates that El Mene is a gentle anticlinal fold with a steep-dipping and strike-faulted northern flank. Drilling has proved a strong asymmetrical Eocene fold at 5,000 feet depth. Unconformably on top of this are 4,000 feet of less strongly folded Agua Clara beds. At the top of these is well marked angular unconformity above which are 1,000 feet of gently folded La Puertas.

The rhythmic repetition of events revealed by this structure is most interesting and significant. Post-Eocene subsidence and sedimentation was succeeded by folding and uplift exactly along the pre-existing Eocene axis. Similarly post-Agua Clara folding was repeated on the same axis. Finally, the third strong folding movement, in post-La Puerta time, was again exactly on the same axis.

At Media, on the eastward continuation of the El Mene structure, the fold is much more strongly compressed, but the same two unconformities have been proved by drilling, namely, at the base of the La Puerta and at the top of the Eocene.

STRUCTURE—FAULTING

As would be expected, very extensive faulting on a big scale is clear throughout the regions not obscured by alluvium. Faulting in general conforms to one or the other of two very well defined trends, namely, east-northeast and north-northwest.

The strike fault downthrowing El Mene on the north was recognized by geologists at an early date. Drilling has proved the downthrow to be 5,000 feet. At Hombre Pintado (10 miles east-northeast from El Mene) the same fault brings Cerro Pelado rocks against Eocene, a stratigraphic difference of at least 5,000 feet. It looks as if this may be a key fault of the region, forming a tectonic division between the sunken northern area of alluvium, and the first exposed foothills.

The general pattern of the core of structures is beautifully exhibited just south of Media, where field mapping has proved a mosaic of small fault blocks, cut off on the north by the major El Mene-Hombre Pintado strike fault (Fig. 12).

A point of considerable interest at both Media and Hombre Pintado, is the unmistakable proof that the center of the structure has collapsed. Each strike fault upthrows away from the fold axis. Media is on the north flank and each block on this flank is upthrown in relation to its neighboring southern block (Fig. 10). In Hombre Pintado either north or south from the axis, each successive block is upthrown, which means that the maximum collapse has been in the center of the structure.

In the southeastern mountainous area rock sheets overthrust several miles

have been mapped. No attempt was made to work out detail, because the intensity of diastrophism there appeared to preclude all possibility of oil.

GEOLOGICAL HISTORY

The history of West Buchivacoa is one of frequent movement. At the close of Eocene time some folding took place. This is proved by angular unconformity exhibited by cores in several Media wells. In the south part of the region (south of Vega Oscura) field mapping clearly proved angular unconformity, at the top of the Eocene at the surface. Evidence from one or two wells, however, indicates that this unconformity was confined to some fold axes only and that in the basins deposition was unbroken.

After the relatively limited post-Eocene movement there was an Oligocene-Miocene period of marine sedimentation, during which the Agua Clara-San Luis group was deposited throughout West Buchivacoa (excepting possibly part of the Northern Plains). Movement and sedimentation then continued together as proved by the erratic distribution of the Cerro Pelado group.

In late Pliocene or early Miocene time there was strong movement followed by the deposition of the La Puerta beds, which rest unconformably on any beds from Eocene to Cerro Pelado. After the close of La Puerta time, possibly during Pleistocene or later, there was a very strong folding which has left some La Puerta beds vertical or even overturned.

The final movement has been one of uplift as proved by gravel terraces at levels up to 2,493 feet (top of Lejia) in West Buchivacoa.

OIL AND GAS RESERVOIRS

In all three fields oil is associated with unconformities. In El Mene production is just above, at, and just below the unconformity where gently dipping La Puerta beds lie on upturned Agua Claras (Figs. 5 and 6). The Cerro Pelado, which should be between the two, is missing. Above the unconformity are La Puerta sand lenses with oil. At the unconformity are La Puerta sands and steeply dipping Agua Clara sands, either or both of which give production (Fig. 7). Below the unconformity, to a maximum proved depth of 600 feet below it, oil is produced from Agua Clara sands.

El Mene provides an interesting illustration of structural and lithological reasons for oil accumulation. At El Mene the main fold axis had a good overburden of La Puertas on top of it which provided sufficient rigidity to prevent crumpling and crushing. This is in marked contrast to the crushed nature of the continuation of this axis eastward. The result was that the Pleistocene movement was restricted to producing a gentle La Puerta fold at El Mene, of a form admirable for accumulating oil. An essential adjunct to this is a 500-foot blanket of mottled clay which has prevented both escape of the underlying oil and ingress of surface water.

While it is impossible to dogmatize on the origin of El Mene oil, it appears

justifiable to say that it can not have originated in the La Puertas; it may have come from the Agua Claras, but has more probably been derived from the Eocene or Cretaceous. This means that most of the El Mene oil escaped as the result of post-Eocene and post-Agua Clara folding. The present-day oil is merely the squeezed-out remnant of a once big oilfield. The evidence from two El Mene

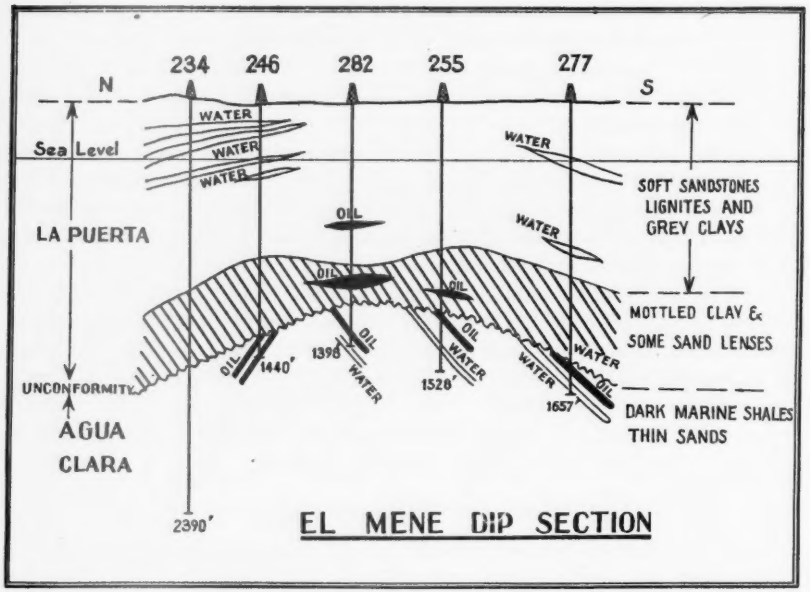


FIG. 5

wells drilled into the Eocene can be regarded as supporting this hypothesis: they found various indications of oil in the Eocene, but no commercial production.

In Media the oil occurs at and above the unconformity where steeply dipping Agua Claras rest on vertical Eocene black shales and thin sands.

The upper productive sand at Hombre Pintado is associated with what appears to be an inter-Agua Clara unconformity. The lower oil sand 1,000 feet deeper is similar but with steeper dips.

The oil in all three fields is found in sands.

In El Mene the La Puerta sands are lenses within mottled clay, and the underlying steeper-dipping Agua Clara sands have salt water below the oil and are cut off and sealed by unconformity above. In both Media and Hombre Pintado the oil sands are cut into mosaics by faults. Proof of this is afforded by Schlumberger logs: wells in both fields are correlated in groups in accordance with the fault blocks in which they are situated.

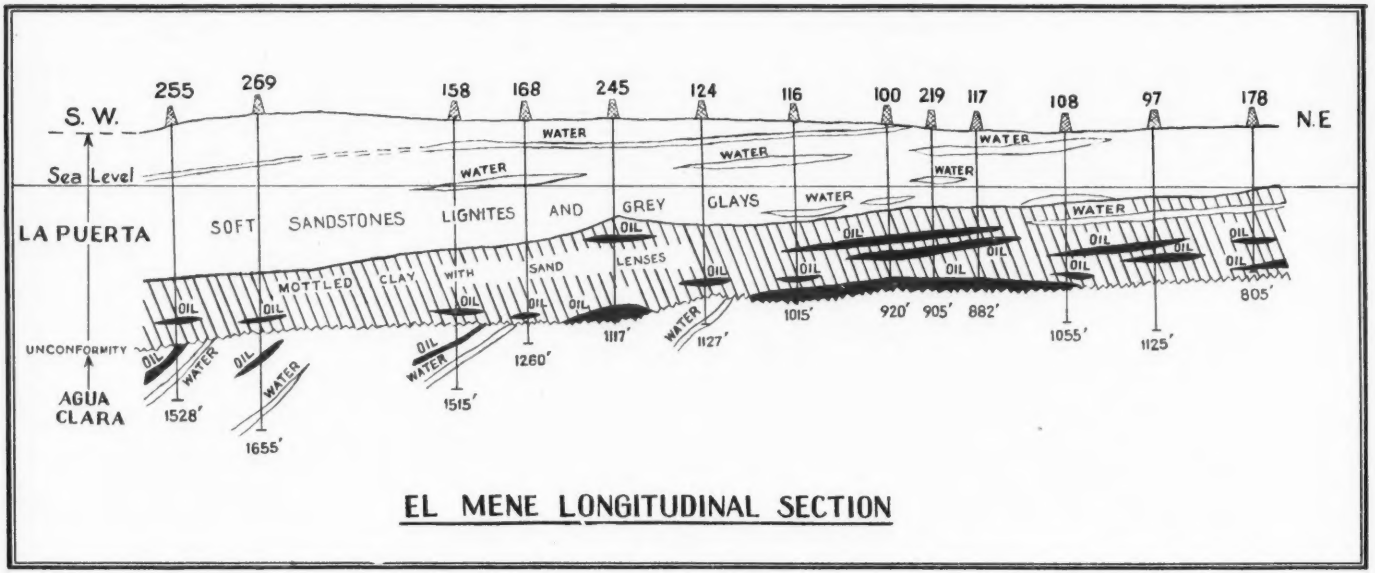

255
269
158
168
245
124
116
100
219
117
108
97
178
S. W.
N. E
Sea Level
WATER
LA PUERTA
SOFT SANDSTONES LIGNITES AND GREY GLAYS
MOTTLED CLAY WITH SAND LENSES
OIL
UNCONFORMITY
AGUA CLARA
1528'
1655'
1515'
1260'
1117'
1127'
1015'
920'
905'
882'
1055'
1125'
805'
EL MENE LONGITUDINAL SECTION

FIG. 6

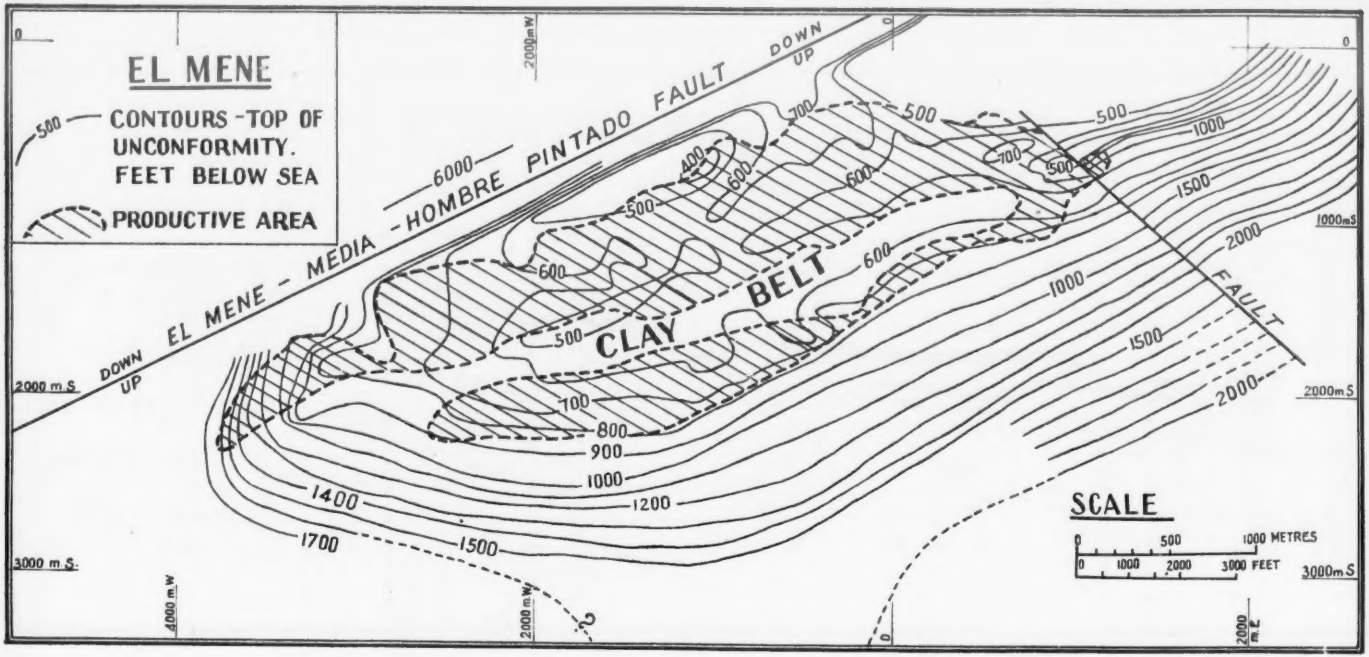

EL MENE
500 CONTOURS - TOP OF UNCONFORMITY. FEET BELOW SEA
PRODUCTIVE AREA
EL MENE - MEDIA - HOMBRE PINTADO FAULT
DOWN
UP
CLAY BELT
FAULT
SCALE
0 500 1000 METRES
0 1000 2000 3000 FEET
2000 m.S.
3000 m.S.
1000mS
2000mS
3000mS
2000 m.W.
4000 m.W.

FIG. 7

RESERVOIR FLUIDS

A comparison of the oils from the three fields follows.

	El Mene	*Media*	*Hombre Pintado*
Specific gravity A.P.I.	.865 32.08°	Average .810 43.2°	Average .904 25.03°
Initial boiling point	55°C.	49°C.	72°C.
	Percentage		
Distillation to 100°C.	12.0	14.0	3.5
Distillation to 125°C.	20.0	24.0	7.0
Distillation to 150°C.	28.0	32.5	10.0
Distillation to 175°C.	34.0	39.5	14.5
Distillation to 200°C.	40.0	47.0	18.5
Distillation to 225°C.	47.0	54.0	24.5
Distillation to 250°C.	55.0	60.5	32.0
Distillation to 275°C.	61.5	67.7	27.5
Distillation to 300°C.	66.0	73.1	41.0
Sulphur content			0.33
Paraffine wax content		0.3	3.21
Casing-head gasoline per 1,000 cubic feet	2.9 U.S. gals.	2.0 U.S. gals.	0.67 U.S. gal.

DRILLING PRACTICE

Drilling commenced in El Mene in 1920 and by the end of 1930, 279 wells had been completed and the field was drilled up (Fig. 8). The average depth of wells was approximately 1,000 feet. The cable system was used almost entirely. This had various advantages: only one small boiler was required per well and rigging-up costs were very small. Normal completion time was about 30 days. With rotary this time would have been greatly reduced, but with the equipment then available, and with the enormously increased set-up charges, it seems doubtful whether at that time rotary would have shown any financial superiority over cable tools for 1,000-foot wells. Whatever view be taken about this, rotary was definitely precluded because the sands in El Mene are erratic in position and are of low pressure. The field was drilled up before Schlumberger electric logging became available in Venezuela. With rotary several hundred feet of coring or an elaborate system of testing would have been necessary in each well or prolific sands might have been missed. With the cable system it is very unlikely that any oil sands were passed up without detection. Were El Mene developed today, due to the epoch-making application of Schlumberger electric logging, entirely different methods would be applied.

Normal casing consisted of a couple of joints of conductor, an 8⅝-inch water string driven into the mottled clay, and a 6⅝-inch oil string. Water shut-off as a whole was so effective that it appeared that cementation would not be of any advantage in the particular circumstances.

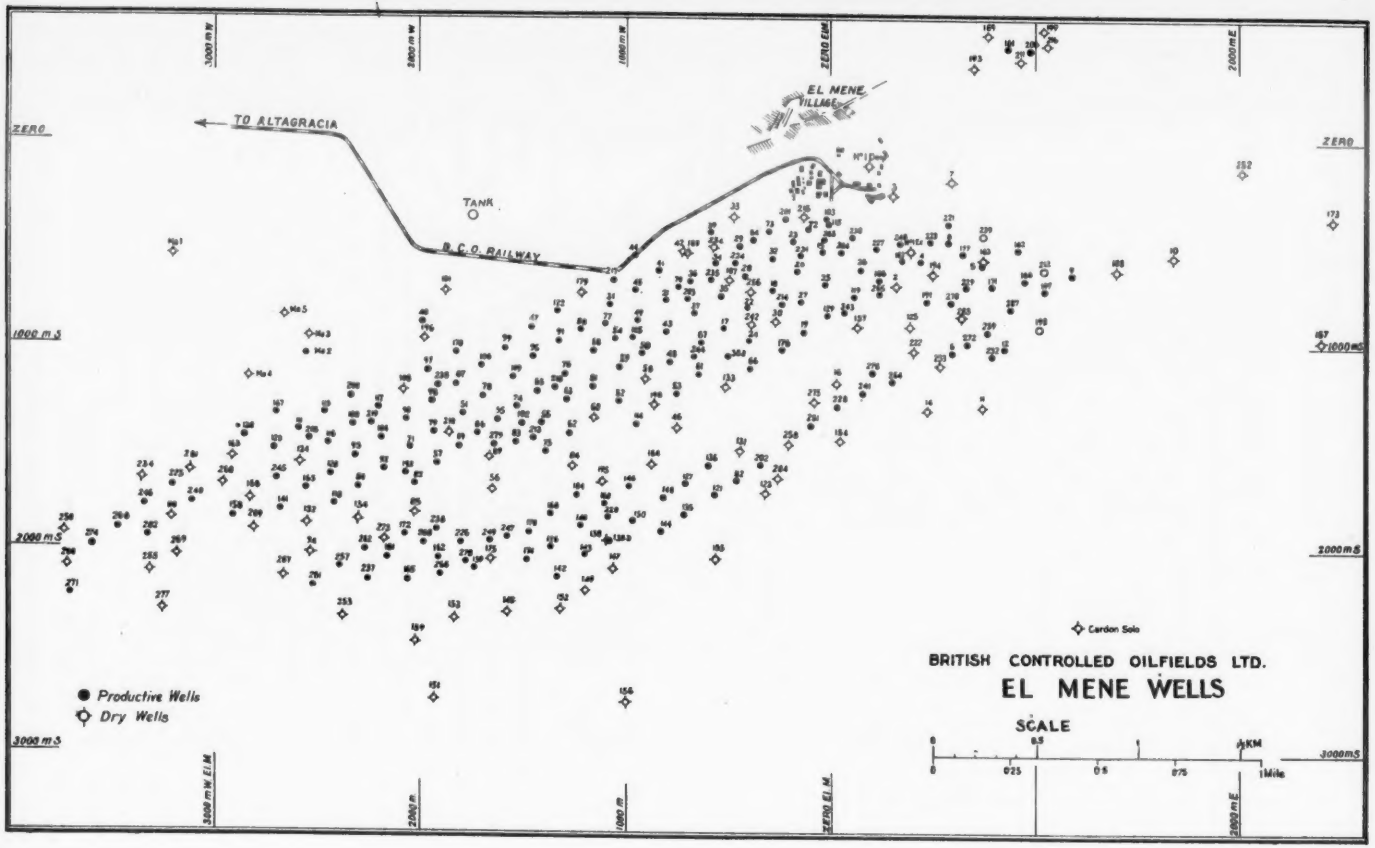

EL MENE VILLAGE
TO ALTAGRACIA
TANK
B.C.O. RAILWAY
ZERO
1000 m S
2000 m S
3000 m S
1000 m E
2000 m E
ZERO EL M.
Productive Wells
Dry Wells
Cardon Solo
BRITISH CONTROLLED OILFIELDS LTD.
EL MENE WELLS
SCALE
KM
Miles

FIG. 8

Since 1930, practically all drilling was by rotary and all wells had electric logs. This applies to wildcat deep wells and the Media and Hombre Pintado fields. In Media, 38 wells were drilled by rotary between 1928 and 1937. Drilling in Hombre Pintado started in 1926 and still goes on. It has all been by rotary.

The total amount of drilling and production from 1920 to December, 1945, is shown as follows.

Field	*Total Footage Drilled*	*Total Barrels Production to Dec., 1946*	*Barrels of Oil Per Foot Drilled*	*Acres Productive*	*Barrels Per Acre*
El Mene	316,149	22,862,000	72.3	867	26,369
Media	125,688	2,632,000	20.9	81	32,493
Hombre Pintado	92,785	3,802,409	41.0	91	41,784
Exploratory	120,707	0	—		

El Mene and Hombre Pintado are still producing. The deepest well drilled by the company was Vega Oscura No. 2—7,611 feet. The shallowest El Mene producer is 675 feet deep.

PRODUCTION—EL MENE

Altogether 284 wells have been drilled in El Mene (Fig. 8). They range in depth from 235 to 6,598 feet, with an average approximating 1,000 feet. Wells are spaced 500 feet apart on a triangular grid.

Many wells flowed initially 2,000 barrels per day and more, with casing pressures of 350 pounds per square inch and less. In 1928 straight gas lift and "maxiflow" (intermittent gas lift) were introduced and were remarkably effective in keeping up production. Re-pressuring and gas drive were tried, and the results were as expected from the geology, namely, that on account of the lenticularity of most of the sands good results were obtained in a small proportion of the wells only, but in these few wells the success was conspicuous and still continues. At present, in its declining stages, the field is producing by maxiflow and pumping.

El Mene consists of a Northern pool and a Southern pool. They are separated by a clay belt running in a strike direction just south of and parallel with the main fold axis (Figs. 7 and 8). The barrenness is due to the complete absence of any porous beds in this zone at normal productive depths.

In the Northern pool there is brackish water associated with the oil, but it is not true edge water. Its salinity averages 450 parts per 100,000 but is not constant.

In the Southern pool the water associated with the oil is on the average twice as saline (900 parts per 100,000) as in the Northern pool. Furthermore, the water is true edge water and has advanced up the flank of the structure in proportion as oil has been withdrawn. The total amount of water produced is estimated at about 20 per cent of the total amount of oil.

For practical and commercial purposes there is no difference whatsoever between Northern and Southern pool oils.

Well No. 32 was completed at 988 feet in 1924 in the Northern pool. It has yielded more than a million barrels of oil or 5 per cent of the total production of

El Mene. It is still producing on the pump. Well No. 126 has produced 900,000 barrels, and five other wells have produced more than 400,000 barrels each and are all still producing.

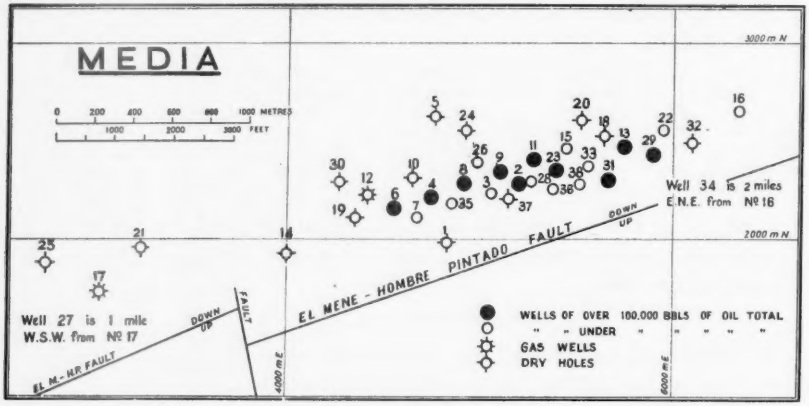

MEDIA
0 200 400 600 800 1000 METRES
1000 2000 3000 FEET
3000 m N
2000 m N
4000 m E
6000 m E
Well 34 is 2 miles E.N.E. from № 16
Well 27 is 1 mile W.S.W. from № 17
EL MENE - HOMBRE PINTADO FAULT
EL M.-HP FAULT
DOWN
UP
WELLS OF OVER 100,000 BBLS OF OIL TOTAL
" " UNDER " " " " "
GAS WELLS
DRY HOLES

FIG. 9

PRODUCTION—MEDIA

Media production is confined to a strip a mile long in a strike direction and ¼ mile wide, which undoubtedly represents a fault accumulation (Fig. 9). The southern wells drill through a buried block of overhanging Eocene into younger beds below, in which the oil occurs. Below the oil they enter Eocene again (Fig. 10). Extensive coring was undertaken from which the position of the Eocene was determined with precision.

The average depth of production is about 3,000 feet. Initial restricted flows were up to 2,000 barrels per day with casing pressures of 1,500 pounds per square inch. The oil is almost identical with that from El Mene except that it is slightly more waxy. The oil occurs in sands and is very clearly recognizable on Schlumberger electric logs. A little salt water was produced with the oil in some but not in all of the wells. Its salinity is 400 to 700 parts per 100,000.

PRODUCTION—HOMBRE PINTADO

The Hombre Pintado structure consists of an anticline of Agua Clara rocks downdropped between two Eocene masses. The structure is cut into a mosaic by faults. Both the distribution and the gravity of the oil have been affected by these faults. The main oil accumulations are approximately at 800 and 1,800 feet depth, both of which horizons represent unconformities. The surprising constancy of the depth in steep-dipping beds is due to the crown of the arch having collapsed, and

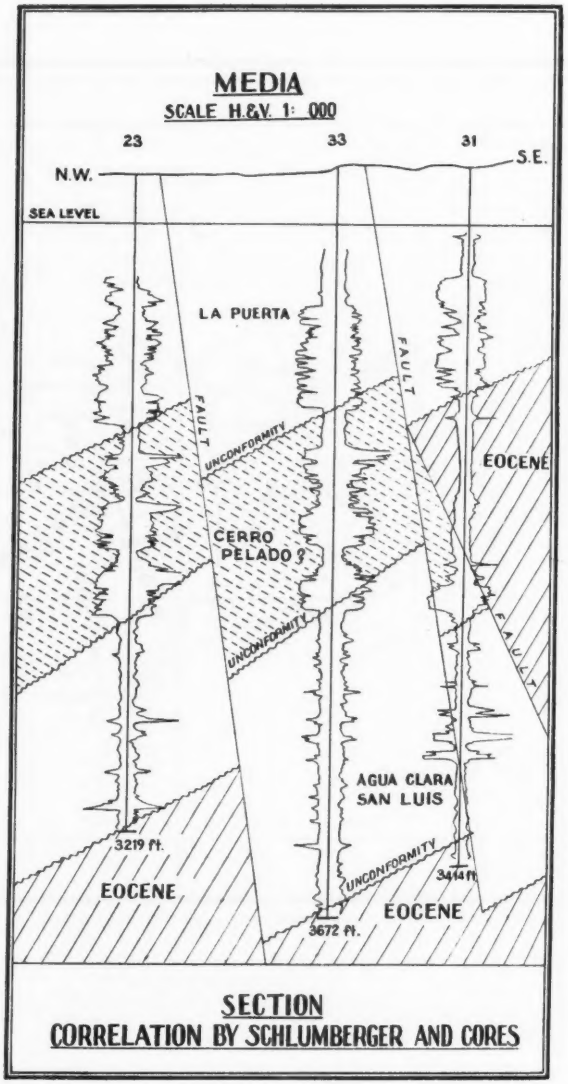

MEDIA
SCALE H.&V. 1: 000
23
33
31
N.W.
S.E.
SEA LEVEL
LA PUERTA
FAULT
FAULT
UNCONFORMITY
EOCENE
CERRO PELADO?
UNCONFORMITY
FAULT
AGUA CLARA SAN LUIS
3219 ft.
UNCONFORMITY
3414 ft.
EOCENE
EOCENE
3672 ft.
SECTION
CORRELATION BY SCHLUMBERGER AND CORES

FIG. 10

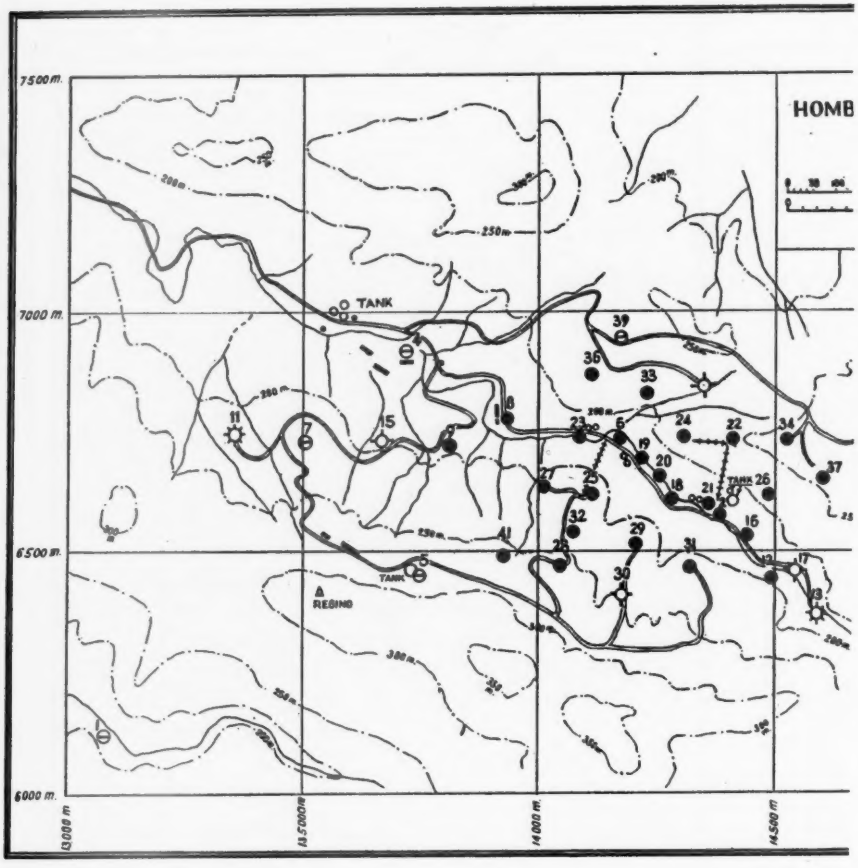
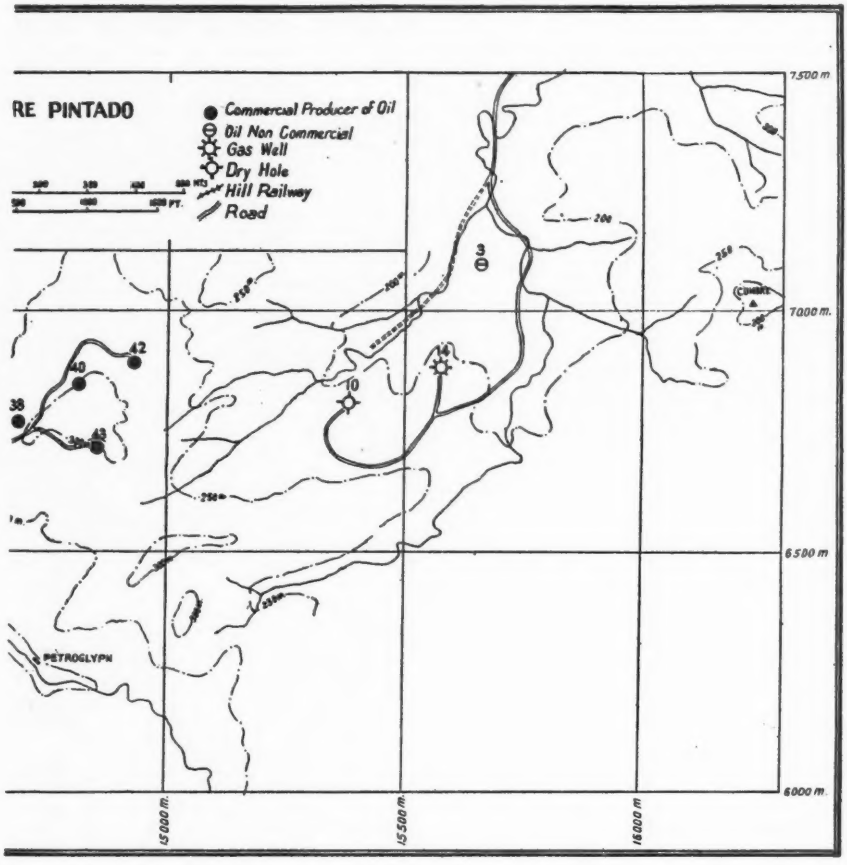

7500 m.
7000 m.
6500 m.
6000 m.
13000 m.
13500 m.
14000 m.
14500 m.
HOMB
TANK
RESIND
TANK
TANK

FIG. 11


RE PINTADO
Commercial Producer of Oil
Oil Non Commercial
Gas Well
Dry Hole
Hill Railway
Road
7500 m
7000 m.
6500 m
6000 m.
15000 m.
15500 m
16000 m
PETROGLYPH
CUMBRE
3
10
14
36
40
42
43

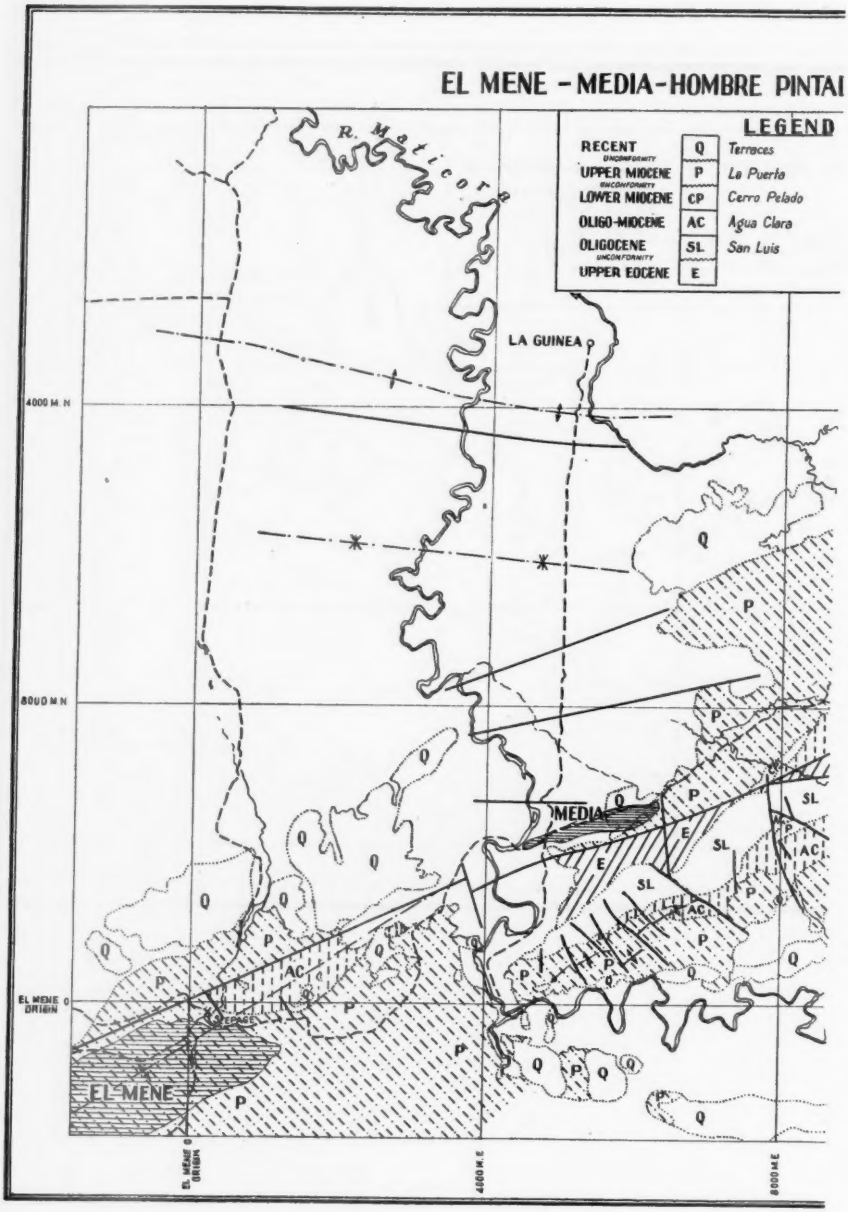
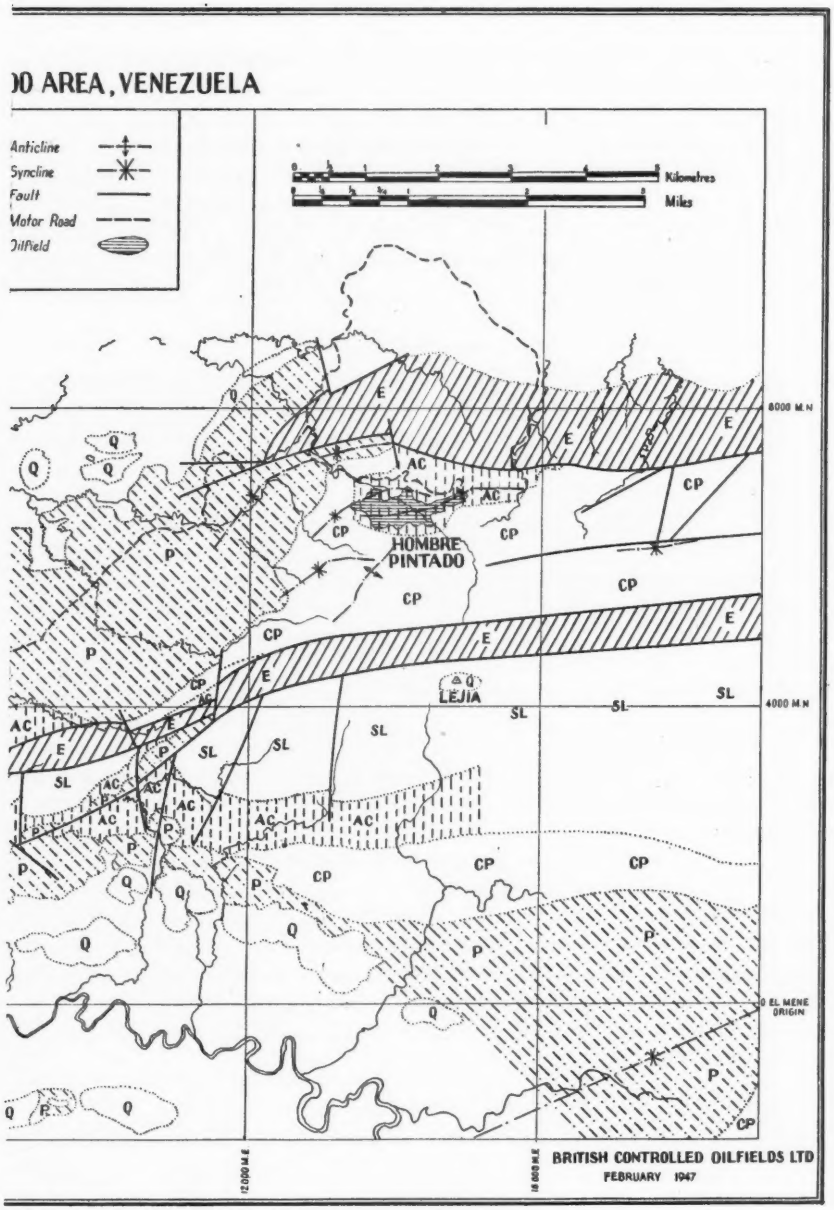

EL MENE - MEDIA-HOMBRE PINTA
LEGEND
RECENT
UNCONFORMITY
UPPER MIOCENE
UNCONFORMITY
LOWER MIOCENE
OLIGO-MIOCENE
OLIGOCENE
UNCONFORMITY
UPPER EOCENE
Q Terraces
P La Puerta
CP Cerro Pelado
AC Agua Clara
SL San Luis
E
R. Maticora
LA GUINEA
4000 M.N
8000 M.N
MEDIA
EL MENE
EL MENE ORIGIN
4000 M.E
8000 M.E

FIG. 12


)0 AREA, VENEZUELA
Anticline
Syncline
Fault
Motor Road
Oilfield
Kilometres
Miles
HOMBRE PINTADO
LEJIA
8000 M.N
4000 M.N
EL MENE ORIGIN
BRITISH CONTROLLED OILFIELDS LTD
FEBRUARY 1947

subsidence of the center has sunk it by an amount roughly equal to the increased depth due to dip of the flanks.

In detail the distribution of oil and salt water is erratic. Both show clearly on Schlumberger electric logs. Many of the wells produce some salt water with the oil. The salinity of the waters varies from 80 to 1,400 parts per 100,000.

Most of the wells are about 2,000 feet deep. Their spacing is somewhat erratic (Fig. 11). This is partly due to the extremely difficult topography of the region, which in some cases necessitated leaning narrow gauge railway tracks against the hillsides to get drilling equipment to the sites. In one case two wells are only 110 feet apart but they do not correlate and show no sign of interference. They are in separate fault blocks.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 31, NO. 12 (DECEMBER, 1947), PP. 2193-2206, 2 FIGS.

EL MENE DE ACOSTA FIELD, FALCON, VENEZUELA[1]

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Pointe-a-Pierre, Trinidad, British West Indies

ABSTRACT

The now abandoned El Mene de Acosta field is situated in the State of Falcon 85 kilometers northwest of Puerto Cabello in the Tocuyo Valley.

The major feature of the field is the asymmetric northeast-trending El Mene anticline of which only the south flank was productive. The accumulation is Oligocene in age and the trap is a combination stratigraphic-structural one.

No. 2, the discovery well, was drilled in 1927 and the field was closed in 1937. Eighty-two wells were drilled, 13 of which were step-outs.

The producing formation, 600 feet in thickness, is the Oligocene El Salto member of the San Lorenzo formation, one of the group of Agua Salada formations.

Approximately 759,070 barrels were produced before the field was abandoned.

INTRODUCTION

This now abandoned field is situated in the State of Falcon, District of Acosta, about 85 kilometers northwest of Puerto Cabello, 17 kilometers from the coast. The terminal during exploration was Piragua near San Juan de la Costa, and during exploitation it was Chichiriviche, with which the field was connected by rail. The major feature of the field is the asymmetric northeast-trending El Mene anticline of which only the south flank was productive.

The field was discovered by Well No. 2 in 1925 drilled by the North Venezuelan Petroleum Company. Surface mapping and seeps led to the drilling. The El Mene anticline is one local dome in a chain of anticlines extending from the sea to El Mene de Jacura, parallel with the Lower Tocuyo River.

In the year 1927 Wells No. 3 and No. 4 were drilled and drilling continued until 1934 when development ceased; after 81 wells had been drilled production was continued by Tocuyo Oilfields Limited until 1937 when the field was shut in. In 1935 Well No. 82, a last outstep and, at the same time, the deepest well in the area, was drilled to 4,776 feet.

The whole acreage was held by Tocuyo Oilfields Limited, who acquired it from the North Venezuelan Petroleum Company Limited in 1928. The concession of 85,600 acres formed part of the Jimenez Arraiz Falcon Concession.

Only about 120 acres were proved productive out of a much larger area tested. The original expectation was to find oil in Eocene or Oligo-Eocene Guacharaca and deeper beds, not cropping out in the El Mene anticline. Wells No. 1 and No. 57 were attempts to test such deeper possibilities. No. 1 did not go deep enough and No. 57 was drilled to 3,931 feet and never completed.

A small topping plant was run to provide gasoline for the use of the company

[1] Manuscript received, February 7, 1947.

[2] Geological, physical, and survey division, Trinidad Leaseholds, Limited. The information given in this paper has been made available by the directors of the North Venezuelan Petroleum Company Limited to whom thanks are due, as well as to H. G. Kugler, who was responsible for the discovery well and who was also connected with the development of the field.

and local inhabitants. Figure 1 gives the geographical situation of the field, surface geology, and well locations.

GEOGRAPHY

The landscape is one of rolling hills covered with dense tropical forest, which had to be cleared to make room for installations and camps. The average relief amounts to about 25 meters with the crest of the hills reaching the 60-meter contour. Drainage is consequent and toward the southeast toward the Tocuyo River, and the lower part of the valleys, tributaries to the Tocuyo Valley, are drowned and, in several cases, contain swamps with perennial lakes. Cienega Pozo Azul and Lake Tacarigua are examples of such drowned valleys. The hill crests are remarkably regular in elevation; all are flattish and obviously remnants of a Pleistocene "Tocuyo peneplain." On some hills, patches of old gravel terraces are still preserved.

Before 1924 only hunters had penetrated the area and no settlement existed. An old one, called El Salto, on the Tucurere River 6 kilometers north of the El Mene field had been abandoned some years before. Access to the field was by means of a 30-kilometer dry-weather road from San Juan de la Costa and by a company-owned 35-kilometer, narrow-guage railroad to Chichiriviche Harbour. The valleys, most of them ravines only, are narrow with little or no alluvial plains. Landslips are common in the cleared areas. In the course of the opening of El Mene de Acosta, the village of San Lorenzo, named in honor of Don Lorenzo Mercado, was built and is now surrounded by a great number of clearings giving the vicinity a changed appearance.

The yearly rainfall fluctuates between 84.93 and 22.6 inches, the month of November being the wettest month. There is a pronounced dry season between January and May. During June and July there occur heavy showers following thunderstorms.

AREAL GEOLOGY

The surface geology is of the very monotonous "Agua Salada" type and most of the outcropping formations belong to the Agua Salada group. Mappable outcrops and key-beds are rare and mapping had to be done by pitting and augering. From the air, the area is almost featureless. On the ground, however, it was possible to outline the main structural features by following a solitary glauconite bed (the Polycarpio glauconite clay) and a sand-clay boundary inside the San Lorenzo formation. Virgin vegetation was a rough guide to mapping. Owing to the soft nature of most of the outcropping formations, geomorphology is largely independent of geology. However, the trend of dip-faulting is parallel with the river courses and, obviously, has affected these.

SURFACE INDICATIONS OF OIL AND GAS

As the name El Mene implies, there are seepages of pitch and oil (El Mene) in the crestal area of the El Mene anticline. Most of these are outcrop seeps

opened by retrograde river erosion. The Menecito seep in the west occurs in the outcrop of a silt underneath a calcareous sandstone and yielded free oil of a gravity of about 18° API in pits dug into the outcrops.

The El Mene main seep, a combined fault and outcrop seep, was impressive and caused widespread impregnation of the surrounding alluvium. Again, free oil seeped into pits and was collected occasionally by roaming hunters from Tocuyo and Capadare. All of the seeps are in the producing sand zone, the El Salto sands of the San Lorenzo formation, and were almost devoid of gas. Separate gas seeps, however, did exist but were visible only during the rainy season, when gas oozing out of discolored white-gray clays and silts bubbled over at a number of points partly in line with faults. The presence of seepages of comparatively light oil was considered a favorable indication and led to investigation of structure and stratigraphy.

STRATIGRAPHY—REGIONAL

The sediments of El Mene de Acosta form part of the Agua Salada group of formations. This formation is discussed in a very detailed manner in a paper by H. H. Renz, entitled "Palaeontology and Stratigraphy of the Agua Salada Group," and scheduled to appear in a forthcoming publication of the Geological Society of America. In view of this, apart from a generalized stratigraphical table, only such information as is deemed necessary for an understanding of the El Mene de Acosta field is given here.

TABLE I

STRATIGRAPHY OF EL MENE DE ACOSTA FIELD

PLEISTOCENE			Alluvial and sub-recent river terraces	
PLIOCENE			*Absent*	
MIOCENE		— ↑	Pozon formation	Huso clay Husito marly clay Polycarpio glauconite clay
		Agua Salada group	*Unconformity* - - - - - - - - - - - - - - - - - -	
OLIGOCENE	Upper			
	Middle	↓ —	San Lorenzo formation	Menecito clay member El Salto sand member
	Lower		Guacharaca formation	Guacharaca sands (Guayaval-La Danta)
EOCENE		Upper	Cerro Mision (Shale) formation	

The oldest beds, encountered only in wells, are the Eocene Cerro Mision shale (*Bulimina jacksonensis*). These dark gray to black, fairly hard shales have not been penetrated completely. They occur under an unconformity or in faulted position and contain little sand. The next younger beds, the Eo-Oligocene Guacharaca formation, consist of an upper zone of sands (Guayaval-Guacharaca sands) and a lower zone of dark gray shales; the transition shale to sand is gradual. The sands

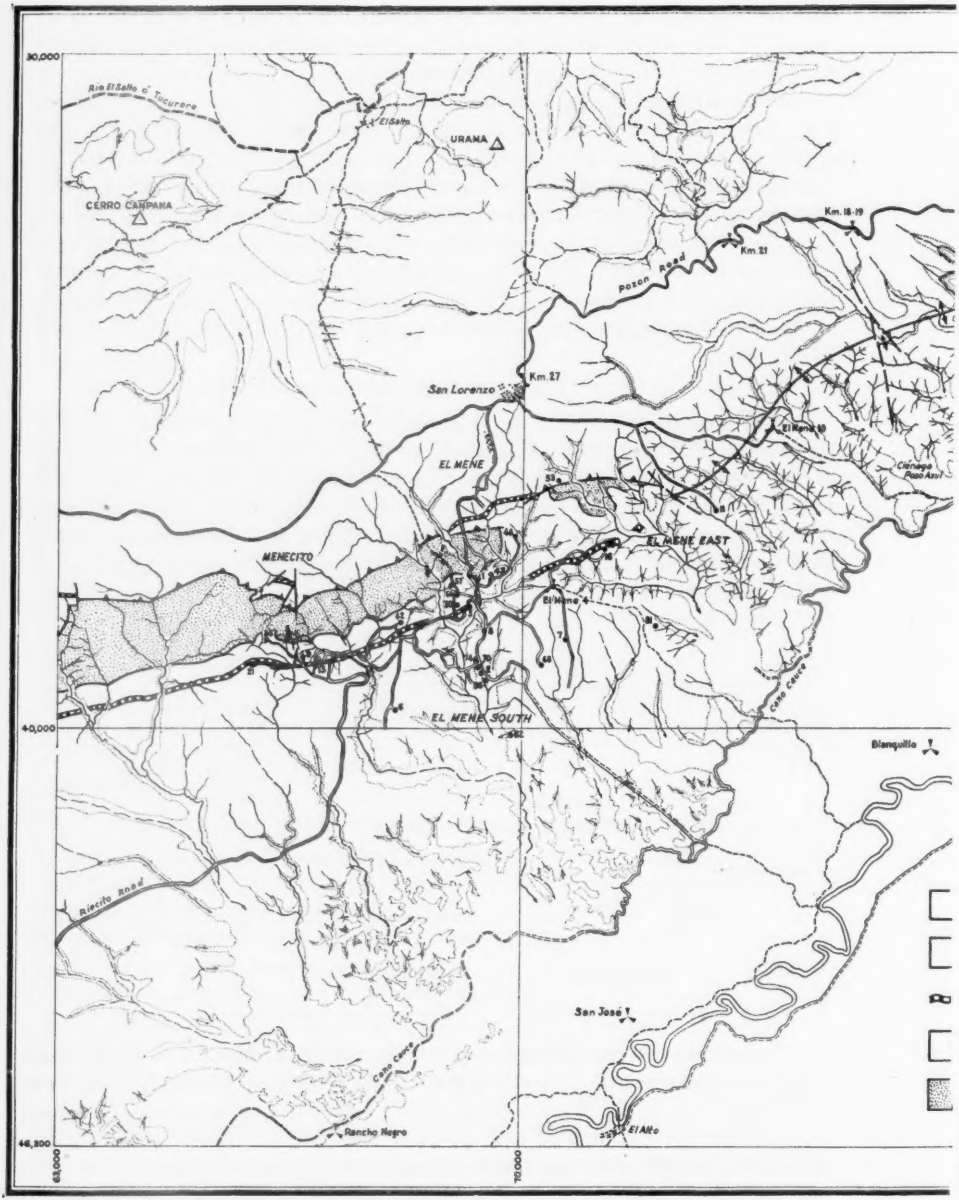
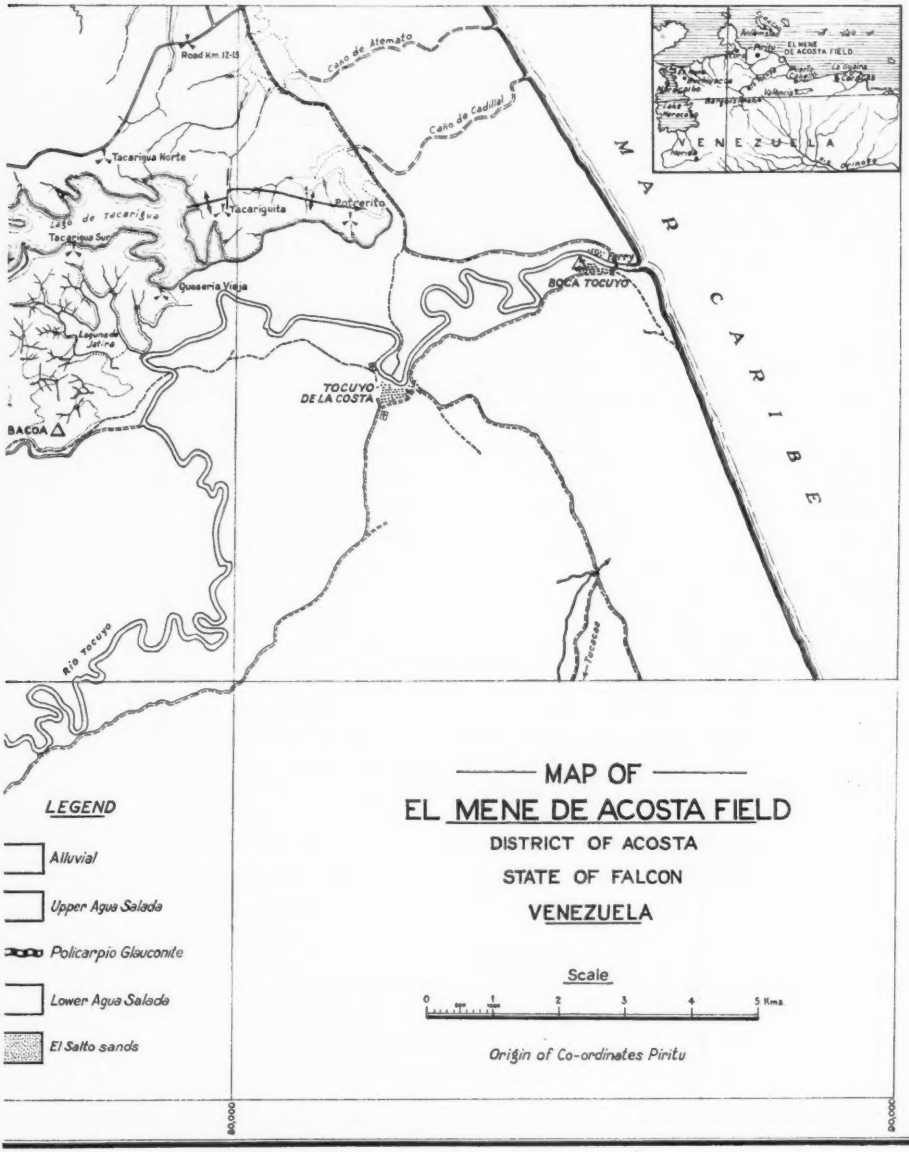


FIG. 1.—Map of El Mene de Acosta field, showing structural trends and outcrops of El Salto Agua Salada crops out only in belt between El Salto sands (dotted) and Polycarpio glauconite. Re

Fig. 1



sands. Boundary of Alluvial is indicated by fine, dotted lines, which mark edge of valley flats. Lower mainder of area between Pozon road and Cano Cauce is upper Agua Salada.

SECTION THROUGH THE EL MENE DE ACOSTA FIELD.

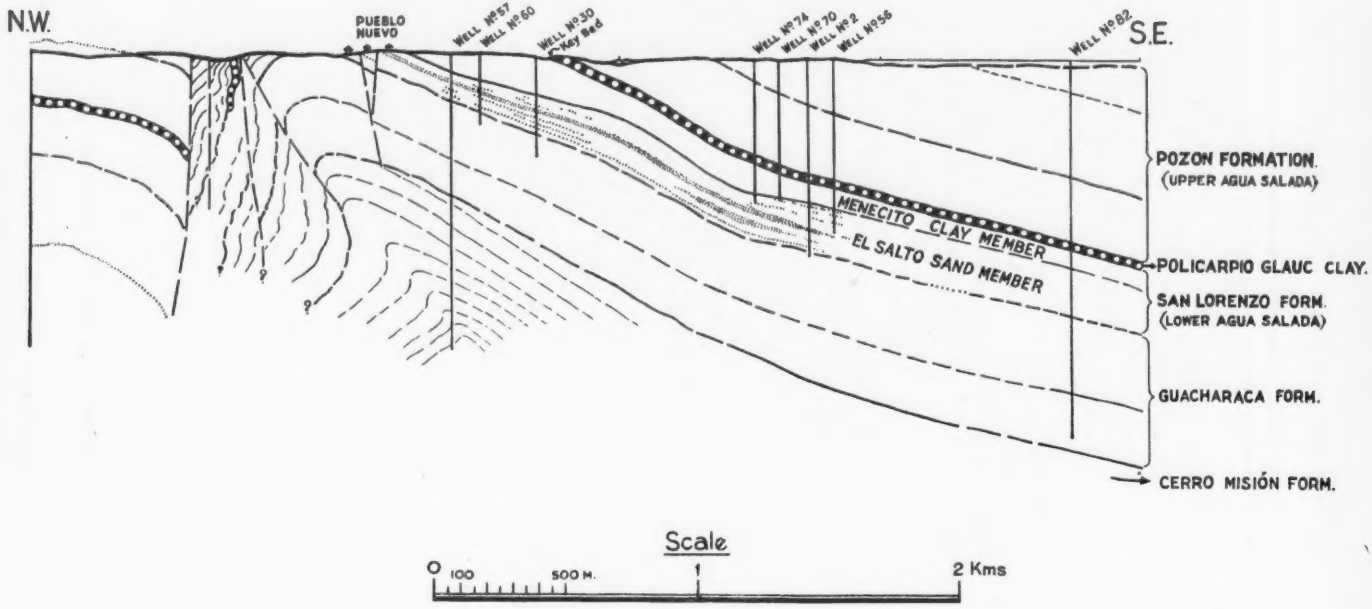


FIG. 2

crop out on another structure and are known at El Mene only from wells. They are rather impure, fairly well consolidated and commonly glauconitic. Lenticularity is not excessive but individual layers are thin (5–20 feet). Overlying these with a gradual transitional contact are the El Salto sands of the Oligocene San Lorenzo formation. These sands contain the producing zone of the field and were formerly known as El Mene sands. The upper boundary of the sands is again transitional. The sands are lenticular and die out in a northerly direction, most of them before reaching the crest of the El Mene anticline or over the crest. Some of the sands become glauconitic near their wedge edge and turn into glauconitic clays. Other sand layers before lensing out become cemented and thus impervious. There are four main sedimentary cycles. Each cycle starts with clay, progresses upward into silt with sand lenticles, then sand lenses, and is topped by a pure sand, cemented in places. There occur a few small orbitoidal limestone bioherms in the area between El Mene and El Menecito, and in the southeast flank in wells, layers of grit and conglomerate occur. The total thickness of the El Salto sand zone amounts to about 500 feet, thickening toward the south.

The four cycles, from top to bottom, are the following.

El Salto sand zone No. 1 (0–100 feet from the top of El Salto sand zone).—These sands are very lenticular, partly gritty, partly very fine; in other words, of very non-homogeneous grade, with shale intercalations. At places there are small lenses of reefal orbitoidal limestones with oysters and bryozoans; glauconite is locally abundant. Among this group there are two to three sands about 50–60 feet thick, of even grade, medium to coarse and of saccharoidal aspect. These sands outcrop and therefore in the wells are water-bearing. Difference of grain size also has affected water and oil distribution.

El Salto sand zone No. 2.—Contains individual beds of sand 10–40 feet thick. These sands are very lenticular and cemented at places in the Menecito area. They are separated from the overlying zone by clay and, being sealed, do contain oil. In El Mene, they are in direct contact with sands of the upper zone and partly water-flooded. At the top of the El Salto sand zone No. 2 there is a streak of glauconitic clay.

El Salto sand zone No. 3.—A group of oil sands 1–5 feet thick with numerous clay intercalations occurs sporadically at El Mene and, as can be expected, is of very limited extent.

El Salto sand zone No. 4.—The sands of this zone are very lenticular, layered, fine and coarse, soft, loose, with silt admixture, and the aggregate thickness of individual beds reaches only about 25 feet. The sands of this zone are not well sorted and not very porous. They grade laterally into silt and glauconitic clays.

The sands of the Guacharaca formation have been found in a number of wells in the El Mene area. They are mostly impure, glauconitic, partly cemented and have little porosity.

The overlying Agua Salada shales are fairly homogeneous and calcareous; the underlying dark blue-gray Guacharaca shales are fairly hard and very homogeneous.

The El Salto sands obviously were deposited in an area of strong but irregular currents over an area with irregular submarine topography, which permitted growth of bioherms and the formation of oyster beds besides offering at places more quiet conditions permitting deposition of well graded, layered sands.

As regards drilling characteristics of the formations, the clays are easy to penetrate but the El Salto sands at that time required extensive rock-bit drilling and it was found that cable-tool drilling was more economical than rotary drilling and, as gas pressures were low and caving absent, most of the wells were drilled and cored with Star-type portable cable-tool rigs.

The field was drilled before the advent of the electric log and only the last well, a step-out, was electrically logged with indifferent results as to correlation between lithology and log.

Correlation of the sands was based on extensive coring and there being no method of core analysis available, producibility was judged qualitatively by visual appraisal of the cores. The Polycarpio glauconite clay served as key-bed. The top of the El Salto sand member was usually logged satisfactorily by ditch sampling, and glauconite streaks and clays persistent enough permitted further checks on the forecast. Core recovery being around 70 per cent, the logs obtained were quite satisfactory for correlation purposes.

STRUCTURE

The El Mene elongate dome is an individual *en échelon* high on the northeast El Mene-Pozon trend of Tertiary folds, subsidiary and almost parallel with the main line of uplifts—that of Guacharaca-Cerro Campana in the Tocuyo Basin. This Pozon-El Mene anticlinal line is situated about 50 kilometers north of the Yaracui sector of the Venezuelan Coast Range and about 15 kilometers north of Cerro Mision.

The surface features are that of a peneplaned, very asymmetrical anticline with indications of plunge in the west-southwest and in the northeast. The anticline is outlined and closed in the Polycarpio glauconite clay locally called the "Key-bed."

The main features of the structure are the comparatively gentle (25° average dip) south flank broken by one set of reversed transversal faults and the distorted, partly overturned, north flank. Erosion has cut into the crest and exposed part of the El Salto sand member.

The Polycarpio glauconite clay marks an unconformity below which the beds are faulted by a set of older faults into segments not expressed in the younger Pozon formation. The dip in the El Salto sands is slightly less than that of the Polycarpio glauconitic clay and the Husito clay of the Pozon formation. In addition, the subsurface strike in the El Salto sands differs from that of the surface beds above the Polycarpio glauconite clay. There is little to say about the detailed structure of the overturned north flank. One well has been drilled into this north flank and, apart from a record deviation of 37°, it confirmed at depth the steep attitude of the beds.

The asymmetry of the fold has led to the assumption of a crestal strike fault of the reversed type. The easternmost outstep wells (No. 10 and No. 11) have given indication of overthrust conditions, which also seem indicated on isogam maps of a torsion-balance survey. From a torsion-balance survey it appears that the El Mene anticline becomes a minor feature at depth and that it is only a wrinkle on a surface regionally rising from the south (the Tocuyo River Valley) toward the north (the valley of the Tucurere and beyond). The eastern seaward extension of the El Mene anticline is cut by combination blatt-dip faults, which displace the crest successively toward the northeast and apparently served to take up the stress caused by the latest phase of folding. Local overturning is proven by the occurrence of a reversed section of Pozon formation, Polycarpio glauconite clay and Menecito clay. The dip of dip-faults is probably east.

GEOLOGICAL HISTORY

The geological history of the El Mene anticline is a parochial one—a leaf out of the history of the Lower Tocuyo Basin, a part of the region of East Falcon, in the fore-deep of the Coast Range. Since the interest is centered around the oil structure of El Mene, the geological history is sketched only in so far as it is related to the oil structure.

The geological history here begins with Eocene during which age mainly argillaceous deposits were laid down in a wide open sea. Folding affected the beds to a certain extent and sand deposition occurred around the time boundary Eocene-Oligocene. The El Mene area received a certain amount of sandy material but not enough to lead to more than a few cycles of impure glauconitic sands, El Mene obviously being in the tail end of an Eo-Oligocene sandy phase.

In the Oligocene age occurred the main cycle of sandy deposits. El Meen was just within reach of an area of sandy deposition. Currents must have been fairly strong to bring coarse gritty material to El Mene and the sea must have been shallow, at times permitting the formation of bryozoan-orbitoidal bioherms. The nearest source for the grit and sand of the El Salto sands was in the metamorphics of the Yaracui region, 50 kilometers away. Sedimentary conditions were favorable for the formation of glauconite and many of the sands grade laterally into glauconite clays. Four cycles of sand were deposited, the coarsest sands being found in the uppermost cycle. There are no clear indications of a delta, but the sandy phase of the San Lorenzo formation was concentrated in three lobes or fingers about 1.5–2 kilometers apart and separated by zones of predominantly clay deposits. These fingers point north-northeast and one was located at Menecito, one at El Mene and one in what was called El Mene East. The lateral variation from sand to clay was regular as a rule and persistent in vertical direction, that is, where the top sand zone was replaced by silts and clays, so were all other zones likewise.

The supply of sand material was much reduced and finally ceased during deposition of Menecito clay, the transition from sand to clay deposition being gradual, and at the end of the Oligocene the region underwent a first phase of folding and faulting, at the end of which the Polycarpio glauconitic clay was de-

posited as an unconformity bed. During the entire Miocene time El Mene was buried beneath an open sea receiving increasing amounts of clay and calcareous clay, resulting in the formation of the upper Agua Salada. Pliocene folding affected the El Mene area and during its end phase the anticline became asymmetrical and, in parts, overturned. The origin of the stress forces must have been in the south-southeast, since the north flank is steep and overturned. During Pleistocene times the area underwent peneplanation and at least three, if not four, terraces, some with gravel, some consisting of clay only, have been traced, and finally the tributaries of the present Tocuyo River have eroded the El Mene anticline at places down to the base of the wedge edge of the El Salto sands.

LABORATORY DATA ON SANDS

Most of the El Mene wells were drilled before the advent of the electric-logging devices and before the adoption of core analysis and therefore no data on porosity, permeability, and saturation are available. The heavy residues of several samples have been investigated by J. C. Griffiths. The mineral assemblage consists of zircon, rutile, tourmaline, apatite, garnet, chloritoid, staurolite, glaucophane, barite (?), chlorite, muscovite, anatase, and biotite. Size analysis of sands by Griffiths is shown in Table II.

TABLE II
GRAIN SIZE ANALYSIS OF SANDS FROM EL MENE WELL 47
(After J. C. Griffiths)

Depth (Feet)	*Median Diameter Micron*		*Coarse Sand*	*Medium Sand*	*Fine Sand*	*Very Sand Fine*	*Coarse Silt*	*Fine Silt*	*Clay*
363– 376	125	0.48	—	7	45	28	16	2	2
Top 425– 440	125	0.63	3	11	36	29	17	2	2
Bottom 425– 440	117	0.70	4	8	33	30	10	7	8
490– 503	109	0.53	1	7	29	44	10	6	3
825– 828	105	0.43	—	4	27	54	9	3	2
958– 976	165	0.48	1	18	51	22	5	2	1
*1,074–1,080	159	0.48	4	13	50	27	—	—	—
*1,122	134	0.58	6	9	39	34	—	—	—

* Calcareous sandstones acidized; analyses recalculated to 100 per cent sand (62.5 microns).

OIL AND GAS RESERVOIRS

The El Mene de Acosta field is a combination trap, stratigraphic-anticlinal, occurring in the El Salto sands of the Oligocene San Lorenzo formation. The three productive patches are all located on the south flank of the El Mene anti-

cline. In each area the respective producing sands died out before reaching the crest and thus before reaching the surface in the eroded apex of the structure. Undoubtedly, a very large amount of oil has been lost from sands tapped by erosion during Pleistocene to Recent time, and some oil is still oozing out of outcropping sands, and outcropping silts are still strongly impregnated.

The El Mene South area produced from the sand zone No. 1, which sands were very lenticular, uneven grade and almost intermixed with water sands, the thickness of the oil-bearing zone varying from 5 to 20 feet.

The El Mene area produced from sand zones 2 and 3. The sands of the zone 3 are fairly coarse, soft, friable, and very interlaminated with silt. Sand streaks varied from 6 inches to 2 feet. Here, the oil sands of zone 2 are rather poorly separated from water sands and made it impossible to produce all oil with the completion method then in vogue.

The Menecito area produced from the sand zone No. 2 which varied in thickness from 5 to 30 feet and the sand is of even, coarse grade and rather homogeneous and capped by a 1- to 5-foot layer of calcareous sandstone. The reservoir was of the single-sand type.

Concluding the general description of the oil reservoir, the statement on type of oil reservoir must be qualified by the epithets residual and marginal. In general, pressures were found to be very low and not sufficient to sustain flow, and gas occurred in pockets only and nowhere in sizeable quantities. Most wells in the Menecito and El Mene areas were drilled with cable tools. Water separated easily from the oil and there was no special tendency to form emulsions.

Initial gas pressure varied as follows.

Sand Zone	*Pounds T.H.P. in Wells*
No. 1	200–400
Nos. 2, 3, 4	60–120 or less

There was a fairly clear stratification of gravity as follows:-

Sand Zone	*Average Gravity*
No. 1	0.8023 S.=44.9 A.P.I.
2	0.8235 S.=40.55 A.P.I.
3	0.8696 S.=31.3 A.P.I.
4	0.8434 S.=36.3 A.P.I.

RESERVOIR FLUIDS

Oil.—A simple analysis of an average El Salto sand oil reads as follows.

(Analysis by T.L.L. from bulk oil, February 12, 1932)

EL SALTO SAND OIL ANALYSIS

Specific gravity	0.8339
Water	Nil
Light fractions at 200°C.	53%
Specific gravity of light fractions at 60°F.	0.7647
Specific gravity of residue at 200°	0.9027
Gas oil	33.45%
Fuel oil	13.55%
The oil is asphaltic in character.	

Water.—An attempt was made to verify correlation of sand zone by means of

water analysis. A good stratification was observed. The reaction values of Cl plus those of SO_4 were taken as 100 per cent and the following classification resulted.

Field	*Sand Zone*	*Sulphate Salinity (Percentage)*
Menecito	No. 1	6.45
	2	11
El Mene	No. 2	7.33–9.3
	3	12.1 approx.
	4	9.9
El Mene South	No. 1	5.4–6.7

In El Mene South the water from lower levels of the El Salto sands showed similar salinities to those from the upper sands, and no proper correlation was possible.

Three examples of waters are the following.

Well No.	*Depth of Sample (Feet)*	*Milligrams per Liter (Parts per Million)*					
		Cl	*HCO_3*	*SO_4*	*Na*	*Ca*	*Mg*
2	1,866–1,870	3,453	1,125	0	2,656	33	43.57
3	680	8,829	2,440	1,589	6,870	148.6	53.41
9	625– 630	1,263	2,092	1,189	8,974	140.9	51.6

(Determinations by H. Erlenmayer, Basle, 1932)

No hardness has been determined. From the table it is clear that the waters were almost brackish and perhaps affected by surface water.

ORIGIN OF OIL

The bulk of oil must be regarded as indigenous to the Oligocene San Lorenzo formation, the clays of which have a character common to any clay associated with oilfields. They are very pyritic, foraminiferal and glauconitic. The lower part of the formation is essentially clay. Resinous substances have been found in cores of El Salto sands and in Well 36, Menecito, where the Sand 2 was absent through pinching-out, minute sand nodules in the silt replacing the sand were full of heavy oil.

Some of the oil may have migrated vertically along faults from underlying Eocene sands.

DRILLING AND COMPLETION PRACTICE

All the wells are to be classed as very shallow. The Menecito and El Mene wells were drilled with portable Star rigs, those of El Mene South with light rotary outfits. A few wells were drilled by rotary to top of the sands and then drilled in with cable tools.

The following table shows distribution and depth of wells.

Part of Acosta Field	*No. of Wells*	*Average Depth (Feet)*
Menecito	28	970
El Mene	29	995
El Mene South	16	2,046
	73	1,215

The other nine wells were step-out wells outside the pools.

The average depth of rotary drilled wells is about 2,000 feet and that of the cable tool 1,000 feet. Drilling method was to drill through the Agua Salada clays to the top of the El Salto sands and then to core continuously into the objective sands. Casing was then set and cemented on top of the objective sand zone and a shop-perforated liner set, resting on bottom. In some wells, liners were not set until later in the producing life.

Casing sizes varied with drilling method. In rotary-drilled wells surface casing was $13\frac{3}{8}$ or 15 inches and the water string 8 inches and the liner 6 inches. In cable-tool wells, the casing sequence depended on the fortune of drilling. Surface casing was usually 15 inches, occasionally 20 inches, and on the average it was necessary to insert two more strings, that is, 12 and 10 or 8 inches.

Drilling through the Agua Salada type shale presented no difficulty although the numerous claystone concretions caused more than one kink in holes. No special mud treatment other than control of water content was necessary, the formation making satisfactory mud, and neither pressures nor caving presented any hazard. Deviations were only checked in a few holes, notably Well No. 57—the attempt to drill a deep test. In this well, deviation clearly varied directly with the hardness of the formation. During drilling, a master gate valve was sufficient to take care of eventualities. Surface installation consisted of a simple Christmas-tree assembly during the short flowing life of the wells.

Tool failures necessitating fishing were common and the daily drilling reports of the earlier wells are full of such remarks as "well idle—no steam, fire-wood wet." Later, residue from the topping plant was burned under the boilers in lieu of green firewood. The Star rigs, of course, were equipped with gasoline motors. The hardness of the formation together with the difficulty to keep roads open, and the necessity for reaming holes made operations rather tedious and completion time varied from 2 weeks to more than a month.

PRODUCTION

During the years 1925–1935, 82 wells were drilled and of these 3 were initial exploratory wells finding the 3 pools; 13 were true step-out wells designed to open new areas; of the remainder 28 were dry holes and the remainder produced a total of 759,070 barrels to the closure of the field. Average initial production ranged between an average of 300 barrels for wells in the Salto sand zone No. 1 from less than 10 feet of sand; 50–300 barrels for the sand zone 2 from about 22 feet of sand; and 50–60 barrels for the remaining sand zones from 15–30 feet of sand. Most wells flowed only for a period of less than one year. Later wells, and es-

pecially Sand 3 wells, had to be pumped almost from the start. Decline varied considerably: some wells declined to 20 per cent of their initial production within 3 months; others (mainly sand zones 2 and 3) took during the same period to 30–60 per cent of their initials.

Some sands were eventually pumped dry, others were invaded by water. Ultimates from wells exhausted before closing the field averaged about 25,000 barrels. The largest well, No. 3, produced about 130,000 barrels.

Well spacing varied with depth; it amounted to 500 feet along strike and 400 feet along dip in the shallow Menecito area and 100-700 feet in the El Mene area where it was irregular. Subsurface communication was proved in the El Mene area. When the field was closed in 1937 it had a pumping potential of about 100 barrels from about half a dozen wells.

The proved areas had been drilled up and step-outs did not find new areas.

The outlet was at Chichiriviche *via* a 35-kilometer 6-inch pipeline, where ocean-going tankers could load from a pier within 100 feet from shore.

The first production of oil was from Well No. 2 in April, 1927, from a depth of 1,864 feet. Shipments of oil started in 1929 and were discontinued in 1936, although the field continued to produce until 1937 mainly for providing fuel for N.V.P. exploration drilling in the Riecito area. About 120 acres had been proved Oligocene and developed out of a much larger negatively tested area.

PRODUCTION—EL MENE DE ACOSTA FIELD

ANNUAL PRODUCTION

(Barrels)

1929	*1930*	*1931*	*1932*	*1933*	*1934*	*1935*	*1936*	*1937*
36,598	211,837	194,792	115,987	89,964	45,489	33,092	23,296	8,015

PRODUCTION PER AREA

Area	*Total*	*Per Acre*
El Mene South	98,679	±4,933
El Mene	341,581	±6,831
Menecito	318,810	±6,376
	759,070	

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 31, NO. 12 (DECEMBER, 1947), PP. 2207-2214, 4 FIGS.

GEOLOGICAL NOTES

CARBON-RATIO THEORY MAY BE SUBJECT TO RE-EXAMINATION[1]

CHARLES J. DEEGAN[2]
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All bituminous coals yield *about identical quantities of methane when carbonized under similar conditions, regardless of their volatile matter content.* This demonstrates that coals not only contain a characteristic substance, which yields large quantities of methane, *but that this substance is present in approximately equal amounts in them.*

Thus, *the methane does not vary from coal to coal as do all other properties,* provided that the carbonizing conditions are the same. This indicates that all coals have a common structure, and it appears that the translucent humic matter of coal is the source of the constant yield of methane.

It is also interesting to note that lignin was found to yield as much methane as peat and certain lignites two or three times as much cellulose or carbohydrates. This is another indication that the main source of peat and coal is the lignin of plants.

The foregoing quotation is a digest of an article by C. R. Kinney in the bimonthly magazine, *Fuel in Science and Practice* (January-February, 1945), pp. 16–24, entitled "The Source of Methane Evolved from Coal on Thermal Decomposition." The italics are here added for emphasis in the present note.

Its possible significance in the carbon-ratio theory is this. The original theory depended on the ratio of fixed carbon to fixed carbon plus volatile matter. If Kinney is correct, then all computations of volatile matter included a constant "K," the methane content. To that extent the volatile matter did not vary directly with the amount of metamorphism that had taken place. The methane content remained constant, at least up to some dividing line beyond which coals could no longer be classified as bituminous.

Re-examination of the carbon-ratio theory may or may not be justified on the basis of this new evidence. It may not alter the results sufficiently to be of any importance. This note is merely to bring the coal research data to the attention of anyone interested in the carbon-ratio theory.

[1] Manuscript received, September 30, 1947.

[2] Associate editor, *Oil and Gas Journal.*

SALT-DOLOMITE INTERGROWTHS[1]

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Recently a suite of three cores was cut in the Richfield Oil Corporation's White well No. 3–1, Sec. 6, T. 12 S., R. 29 E., Chaves County, New Mexico, in the upper Yeso formation of the Permian from 3,445 to 3,499 feet. In the past, from studies of sample cuttings from several wells in this area, there had been reported a porous dolomite associated with anhydrite and shale, about 250 feet thick, commencing about 300 feet below the top of the Glorieta sandstone. The cores which were cut to investigate the oil possibilities of this zone are of geologic interest in that they exhibit (1) sedimentary relationships generally considered incompatible, and (2) pseudo-porosity in dolomite as a result of solution of salt from a salt-dolomite mixture.

The following description of this suite of cores was made by the writer. The symbols following each popular designation of color refer to the Munsell values of these colors, made by direct comparison of the cores with the Rock Color Chart prepared by the Inter-Society Rock Color Committee.

CORE NO. 6: 3445–3461 FEET. RECOVERY 14 FEET, 2 INCHES

Feet	*Inches*	
2	7	Anhydrite, yellowish gray (10 YR 8/2) to light brownish gray (10 YR 6/2), generally massive; scattered fine salt crystals up to 1/16 inch diameter, 2 to 4 inches from top, resulting in "pitting" of outside diameter of core; lower 10 inches contains a few thin gray shale partings
1	5	Mixture of medium gray (N 5) bentonitic shale and salt, associated with several ½-inch layers of white anhydrite; salt dissolved from outer ½–1 inch, resulting in numerous rough irregular cavities
4	11	Mixture of pale brownish gray (5 YR 7/1) anhydrite and salt, well bedded, and characteristically "pitted" as result of solution of salt on outside diameter of core
2	11	Chiefly salt, colorless, containing minor scattered irregular inclusions of white anhydrite
1	4	Shale, medium gray (N 5), bentonitic, containing minor embedded salt crystals and salt veinlets, and a few scattered lenses of white anhydrite ½ inch thick in a vertical direction; few scattered cavities present as result of salt solution
	4	Chiefly anhydrite, brownish gray (5 YR 5/1), and subordinate salt, characteristically heavily "pitted" as result of solution of salt on outside diameter of core
1	3	Chiefly shale, dark gray (N 3), bentonitic, well laminated in lower 10 inches, associated with subordinate salt and light gray (N 8) anhydrite. Upper 5 inches shows a moderate amount of brecciation and a few narrow salt veinlets

CORE NO. 7: 3461–3480 FEET. RECOVERY 8 FEET, 11 INCHES

	4	Very light gray (N 9) anhydrite, weak red (10 R 4/2) and medium gray (N 5) shale, and salt, highly cavernous (3 fragments)
	10	Shale, medium gray (N 5) with a few pale reddish brown (10 R 5/4) streaks in lower 4 inches, subordinate salt and polyhalite (?), and traces of clastic, bedded anhydrite lying parallel with shale laminae. Locally highly cavernous as result of salt solution (Fig. 1, C)
	5	Shale, dusky red (10 R 3/2), and subordinate pale orange salt; bedding distinct, but shale is generally highly cavernous; salt and shale appear contemporaneous (Fig. 1, A)
	3	Shale, medium gray (N 5) with few pale reddish brown (10 R 5/4) streaks, well laminated; traces of clastic (?) anhydrite and salt; unit is scarcely cavernous

[1] Manuscript received, October 28, 1947.

[2] Richfield Oil Corporation. The writer is indebted to Charles F. Henderson for photographic work.

Feet	*Inches*	
1	3	Chiefly anhydrite, medium gray (N 6), with subordinate salt, traces of medium gray (N 5) shale and polyhalite (?); locally highly cavernous as result of salt solution.
1	9	Chiefly salt, colorless, and subordinate $\frac{1}{8}$–$\frac{1}{2}$-inch irregular disconnected patches of very light gray (N 9) anhydrite
1	10	Chiefly shale, medium gray (N 5), grading to dark reddish gray (5 R 4/2) in lower 6 inches, generally well laminated; subordinate light orange-colored salt and clastic (?) bedded anhydrite; highly cavernous, with $\frac{1}{2}$–2-inch openings due to salt solution (Fig. 1, B)
	11	Chiefly shale, medium dark gray (N 4), laminated, containing minor $\frac{1}{8}$–$\frac{1}{2}$-inch layers of anhydrite, and traces of salt; scarcely cavernous; uneven contact with unit below
1	2	Dolomite, dark brownish gray (5 YR 3/1), finely crystalline, contains abundant clear salt crystals $\frac{1}{16}$–$1\frac{1}{4}$ inches in diameter, and a few smaller veinlets $\frac{1}{16}$ inch in width. Large salt crystals contain inclusions of dolomite, suggesting a graphic texture commonly seen in igneous rocks. Outer diameter of core highly porous as result of solution of salt; fresh surfaces inside core are non-porous (Fig. 3, b)

CORE NO. 8: 3480–3499 FEET. RECOVERY 11 FEET, 5 INCHES

4	2	Dolomite, dark brownish gray (5 YR 3/1) finely crystalline, containing several $\frac{1}{4}$–$1\frac{1}{4}$-inch layers of anhydrite-dolomite-salt mixture in upper 24 inches (Fig. 2); entire core made up of varve-like layers, $\frac{1}{4}$–2 inches thick, of dense, very finely crystalline dolomite practically free of salt, alternating with $\frac{1}{8}$–$\frac{3}{4}$-inch well laminated layers of finely crystalline non-porous dolomite containing appreciable intergrown salt crystals 1/25–1/50 inch in diameter (Fig. 4). Solution of salt from latter layers by drilling water results in appreciable very fine porosity and in erosion of dolomite in outside diameter; the harder salt-free layers stand out in relief on core. Upper 20 inches of core are fractured and cavernous as result of solution of primary and secondary salt. Fresh surfaces show no porosity. Dolomite appears partly clastic
1	3	Anhydrite, light olive-gray (5 Y 5/1), massive, containing a $\frac{1}{2}$-inch shale streak, silty, medium dark gray (N 4), 6 inches below top. Fractures in shale contain veinlets of orange salt $\frac{1}{32}$–$\frac{1}{16}$ inch in width
1	6	Shale, medium dark gray (N 4), bentonitic, interbedded with subordinate light gray (N 8) anhydrite and traces of salt. Few small salt solution vugs; weak salty taste on fresh shale breaks
	7	Anhydrite, medium gray (N 6), massive
1	2	Shale, medium dark gray (N 4), bentonitic, $\frac{1}{16}$–3-inch beds, interbedded with anhydrite, medium gray (N 6), $\frac{1}{16}$–1-inch beds. Bedding distinct, and undistorted. Shale locally fractured and containing $\frac{1}{16}$-inch veinlets of moderate reddish orange (10 R 5/8) and colorless salt
2	9	"Redbeds": shale, weak brown (5 YR 3/2), little medium gray (N 6) in upper 10 inches, containing minor anhydrite streaks and fragments, moderately brecciated and bedding much distorted; subordinate light brown (5 YR 6/4) to moderate brown (5 YR 4/4) and colorless salt; highly cavernous as a result of solution of what appears to be principally secondary salt

The salt associated with dolomite and shale in these cores is obviously of both primary (contemporaneous) and secondary origin. Secondary salt either as fracture-filling or intrusion into a host rock is common in nature; the close association of primary salt with dolomite and shales is not common, and almost nothing can be found in the published records on this subject.

Evidence for the primary origin of a part of this salt is as follows.

1. The gray and red shale beds, excepting where brecciated and carrying secondary salt, show even, scarcely disturbed bedding. If the salt had grown following deposition of the shale, it would have had to displace the enclosing rock by force of crystallization, and the shale therefore should be highly deformed. Epigenetic replacement of shale by salt is considered unlikely.

FIG. 1.—Cores of red shale (A) and gray shale (B, C) showing large pits as result of solution of included salt during coring. Bedding in B and C is distinct and regular, and suggests syngenetic origin of salt with shale.

2. When a fragment of the dolomite containing salt crystals is immersed in water, the salt dissolves and the residual rock is highly porous, friable, and crumbly (Fig. 3, A). If the dolomite had been deposited free of salt, it should not have been laid down so loosely, with almost unsupported grains. It is doubtful if this rock would remain undisturbed under loading during sedimentation.

3. In the varve-like layers of intergrown salt and dolomite, alternating with essentially salt-free dolomite, neither of which is disturbed, the salt probably has a very nearly simultaneous relation to the dolomite, because it is unlikely that the salt solution could circulate through a very finely porous dolomite without leaving some incompletely filled pores. The salt-dolomite mixture in the cores is completely non-porous.

FIG. 2.—Core of anhydrite mixed with small amount of dolomite and salt (A), interbedded with salt-dolomite mixture (B). Thin laminations in B suggests clastic origin of part of dolomite. Anhydrite may also be clastic in origin. Note extremely porous condition of parts of salt-dolomite layers as result of salt solution on outside diameter of core.

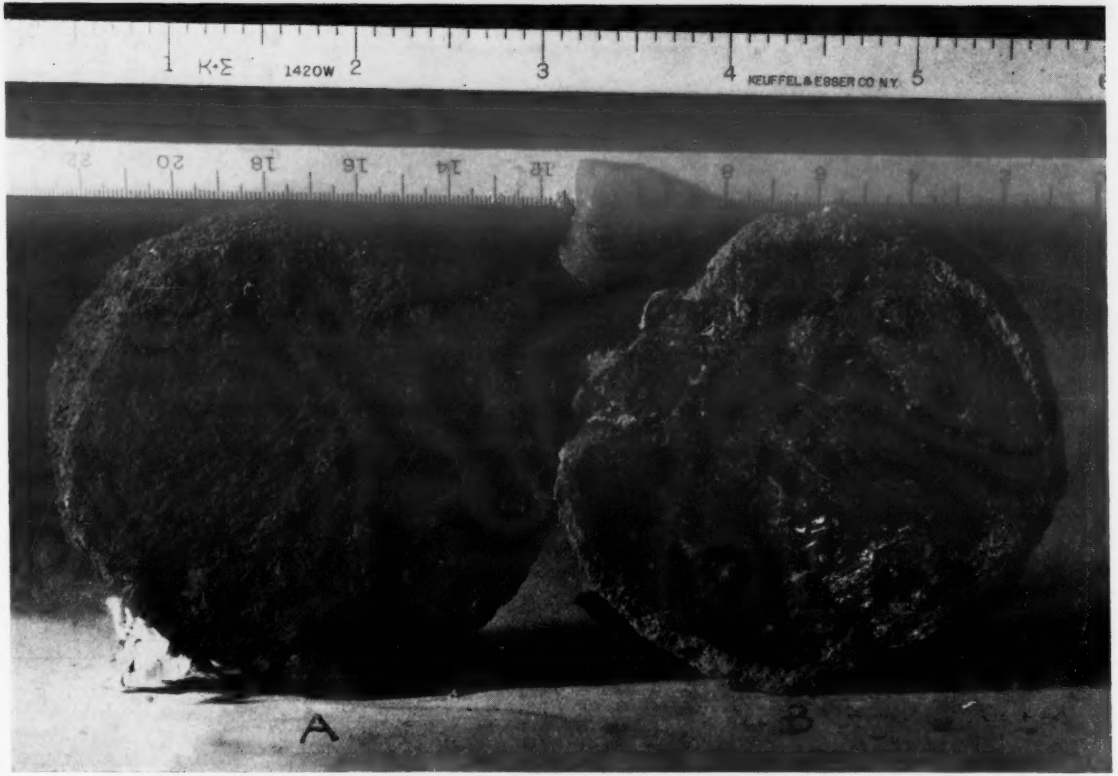

FIG. 3.—View of two matched pieces of core shows change that takes place in salt-dolomite layer (B) after immersing rock in water (A). Light porous ring around B shows depth of solution of salt during coring. Bright area in lower part of B, outlined by dashed line, shows outline of large salt crystal intergrown with dolomite, and having a graphic texture.

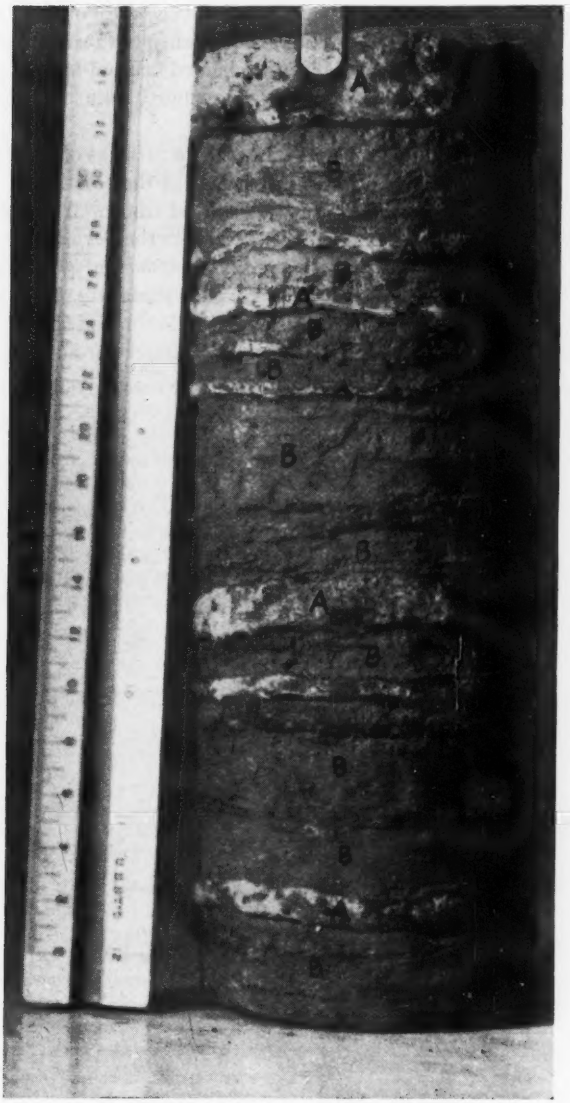

FIG. 4.—Rhythmic banding of layers of generally salt-free dolomite (A), interbedded with dolomite containing very fine salt crystals. Solution of salt from salt-dolomite layers during coring results in friable pseudo-porous dolomite, and consequent erosion of soft layers makes salt-free layers stand out in relief. The almost laminated bedding in soft layers (B) suggests clastic origin of that dolomite.

No attempt is to be made to explain in detail the origin of these associations. It will suffice to say they do occur, and are probably the result of shifting of an extremely delicate geochemical balance in a barred or semi-barred basin. A part of the problem is simplified somewhat by the possibility that some of the dolomite may be of clastic origin.

Of economic importance is the fact that sample cuttings of the dolomite have a remarkable pseudo-porosity which is the result of the solution of the included salt. Artificial porosity such as this, as determined from well cuttings, accounts for the inability of dolomites in similar association in the Permian or other basins, to contain oil or other fluids despite favorable structural position. Perhaps a re-examination of critical dry holes in the Permian basin will reveal many similar instances of pseudo-porosity, and cause a revision of some of the petroleum prospecting ideas in all salt basins. Doubtless there are fewer porous zones in Permian dolomites than well-cutting examination indicates.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 31, NO. 12 (DECEMBER, 1947), PP. 2215-2221

REVIEWS AND NEW PUBLICATIONS

* Subjects indicated by asterisk are in the Association library, and are available, for loan, to members and associates.

IGNEOUS MINERALS AND ROCKS, BY ERNEST E. WAHLSTROM

REVIEW BY LEROY T. PATTON[1]
Lubbock, Texas

Igneous Minerals and Rocks, by Ernest E. Wahlstrom. 367 pp., 124 figs. John Wiley and Sons, Inc. New York (1947).

Professor Wahlstrom has preformed a very great service in bringing together in concise and usable form data and methods of study of igneous rocks and minerals. The book is written in clear and understandable language, a commendable feature not always found in textbooks on this subject.

The book is well illustrated. The block diagrams, such as those showing the orientation of the idicatrix, are excellent and should be of great help to the student in grasping principles which are sometimes somewhat difficult. The photomicrographs which are used abundantly to illustrate the different minerals are good, but in a few cases the photography is not as good as might be desired.

A commendable feature of the book is the inclusion of tables of identification both for use with thin sections and for use with immersion methods. Textbooks containing tables only for use with thin sections or only for use with immersion methods are an annoyance, and it is a relief to find a text which includes both.

On the whole this is a very valuable book and should meet with wide acceptance.

[1] Professor of geology, Texas Technological College. Review received, October 6, 1947.

THE PULSE OF THE EARTH, BY J. H. F. UMBGROVE

REVIEW BY THOMAS A. HENDRICKS[1]
Washington, D. C.

The Pulse of the Earth, by J. H. F. Umbgrove. 358 pp., 8 pls., 204 figs., 12 tables. 6.75×9.5 inches. Cloth-bound board covers. Martinus Nijhoff, The Hague, Netherlands (1946). Price, Gld. 20,–. In English.

Professor Umbgrove has produced in *The Pulse of the Earth*, a book that is best described as inspirational and thought-provoking. The reader who is looking for a set of dogmatic statements or conclusions with regard to the major problems of geology will not find them here. Rather he will find a scholarly review and summation of many of the more basic treatises on the most theoretical problems in geology combined with a critical analysis and elaboration by a singularly widely read and profound scientist. It is a book that is worthy of the careful study of any geologist, and from its character it will most frequently be consulted and referred to by those geologists whose inclination is toward the more purely scientific aspects of geology.

The Pulse of the Earth is constructed on the thesis that the various groups of geologic phenomena are genetically related to one another, that these processes have a common cause, and are cyclic or repetitive. Types of phenomena are treated in successive chapters

[1] Staff geologist, United States Geological Survey. Review received, October 25, 1947. Published by permission of the director of the United States Geological Survey.

and the summation of all types of phenomena into a chronological and integrated whole is attempted only at the end of the book.

The chapter headings with the number of pages devoted to each follow.

	Pages		*Pages*
Space and time	25	Island arcs	73
Mountain chains	17	The floor of the oceans	40
Basins and troughs	23	Ice ages	31
Crust and substratum	23	The rhythm of life	6
Oscillations of the sea level	8	Linear patterns	27
The continental margin	47	The pulse of the earth	5

There are 204 text figures that are well chosen and well used. Most of them are clear and require no elucidation. Unfortunately, at a few places, such as in the chapter on "Island arcs," some of the illustrations fall so far from their text references as to constitute a handicap to continuity of reading. In 8 pages and 2 tables, most of the content of the book is presented in consolidated form. In addition, an appendix of 26 pages of two columns each of fine type constitutes an elucidation of the plates and figures, that many readers will consider the most valuable contribution of the book.

References given at the end of each chapter include many of the more comprehensive papers in geology and are well tied in to the text. The text and references are a guide to the literature that is most useful. There are also numerous text references and footnotes that are used to good effect.

The index is brief but adequate. Typographical errors are numerous, but they do not impair the book seriously. That more important errors are not present is a tribute to Professor Umbgrove's command of English.

Most of the chapters are adaptations of lectures delivered at Cambridge, Delft, The Hague, and Leyden. Therefore, it is not surprising that there is a general lack of balance between chapters. Those on "Oscillations of sea-level" and "The rhythm of life" are so brief that they can not be considered adequate by reasonable standards. Some chapters, such as that on "Mountain chains," contain more nearly complete but still rather sketchy treatment of the subject. On the other hand, the chapters on "Island arcs," "The continental margin," and "The floor of the oceans" are comprehensive and outstanding.

The principal conclusions in *The Pulse of the Earth* are that several events occur in a sequence that extends over a period of about 50 million years and recurs in each succeeding 50-million-year period. In addition, there is a cycle of about 250 million years that results in each fifth sequence being characterized by intensification of each of the component events. Two of these major cycles are believed to have occurred at the end of Paleozoic and during the Pleistocene. It is suggested that the 250-million-year cycle is related to the rotation of the galaxy of which the earth is a part, but no specific cause for the 50-million-year cycle is cited. The repetitive events, in order of occurrence, are: (A) regression of seas from filled geosynclines, compression and folding, and the intrusion of acid batholiths; (B) elevation of folded belts into mountain chains, domal uplifting, basin and geosyncline formation during a period of decreased compression; (C) marked differentiation of climatic zones, widespread glaciation, marked faunal and floral changes during a period of maximum topographic diversity; (D) base-levelling of mountains, a rise of sea-level, and the disappearance of glaciers during a period of stability and erosion; and (E) maximum marine transgression accompanied by extrusion and eruption of basic magmas.

Professor Umbgrove is, naturally, at his best when treating with subjects closely related to the more extensive phases of his own past work, for example, in the discussions that center around the East Indies. However, even there the critical reader will probably discount the tendency of the author to emphasize his classification of basins and troughs

and will detect a definite straining to fit all basins into the classification rather than to make a classification fit the basins.

Many readers will find themselves, like the reviewer, insufficiently informed on world geology to evaluate properly Umbgrove's discussions of some topics. In fact, it is difficult to follow some of the arguments because of their conciseness and the assumption of knowledge of basic data that are too voluminous to include. On the other hand, those same discussions will open lines of thought that many geologists will be able to apply to specific problems in which they are interested.

American geologists are likely to be impressed with what appear to be inaccuracies in references to American geology. Some of these result from over-simplification or unwarranted generalization in the statement of factual data. An example that may be cited (where Umbgrove follows Born) is

> . . . the Mesozoic sediments of the geosyncline from which the Coast Ranges and the Sierra Nevada subsequently emerged, could not possibly have come from the east, since a wide zone, extending as far as—and including—the Rocky Mountains lay beneath the sea at that time.

There are many areas between the east front of the Rocky Mountains and the Sierra Nevada where there is no evidence of Mesozoic seas, and some areas were undergoing erosion during Mesozoic time. In fact, Schuchert has described a positive area there in Mesozoic time that he called the Cordilleran Intermontane geanticline.

The tendency toward over-simplification and generalization appears markedly in discussions of earthquake zones, deep-focus earthquakes, and their relationship to the structural pattern of Japan. Japanese literature contains much excellent material in English and German that if properly used would greatly strengthen these discussions.

A second source of what may be considered inaccuracies lies in one feature inherent to a treatise of the comprehensive nature of *The Pulse of the Earth*, namely, the fact that the subject is so broad that the author must rely for many of his data on previous regional treatises which are themselves compilations based in large measure on the work of others. Thus, the time lag between the completion of studies of specific local problems and their incorporation in a study of this type is about 10 years. These facts are illustrated in the references on North and Central America cited at the end of the chapter on "Mountain chains." There, about two-thirds of the papers cited were published in foreign journals and about half by foreign authors. Only one of the American sources cited, the "Tectonic Map of the United States," was published after 1940.

Some of the arguments may fall short of what many readers would wish. In discussions relative to centrifugal development of marginal deeps, the author has a tendency to favor that concept, but cites as exceptions marginal deeps lying on the side facing the continental shield. The fact that those deeps are marginal to foundered landmasses such as Appalachia and Llanoria, and possibly with regard to those landmasses display a centrifugal relationship, is ignored. This may be because great permanence is attributed to continental shields and, therefore, foundered landmasses can not be defunct shields.

One of the features of *The Pulse of the Earth* that will make a lasting and favorable impression is the ability of the author to avoid dogma. His attitude regarding rigid rules in fundamental geology is well illustrated in the latter part of his introduction to a discussion of "Island arcs," where he comments that: "Once more we learn that be [the] earth's crust is not built up by a single dynamic activity that can be expressed in a simple formula or law."

The foregoing paragraphs appear to focus undue attention on minor weaknesses of a fine book. With that in mind, it should be stated that the principal reaction of the reviewer while reading *The Pulse of the Earth* is regret that he did not have the opportunity to be a student of Professor Umbgrove.

REPORTS ON PROVED RESERVES OF CRUDE OIL, NATURAL GAS LIQUIDS, AND NATURAL GAS

REVIEW BY PAUL WEAVER[1]
Houston, Texas

Reports on Proved Reserves of Crude Oil, Natural Gas Liquids, and Natural Gas, December 31, 1946, by the American Gas Association (420 Lexington Avenue, New York 17, N. Y.), and the American Petroleum Institute (50 West 50th Street, New York 20, N. Y.). 16 pp.

Since 1935, the American Petroleum Institute's Committee on Petroleum Reserves has published each year, in the April issue of the A.P.I. *Quarterly*, its figures on proved petroleum reserves as of December 31 of the preceding year. These figures, arranged by states, have shown: (1) the estimated proved reserves at the beginning of the year (December 31 of the previous year); (2) the changes due to extensions and revisions during the year; (3) the proved reserves discovered in new pools during the year; (4) the production during the year; and (5) the total estimated proved reserves as of the end of the year

The most recent report of this committee bringing these statistics to December 31, 1946, is a departure from previous reports in two respects: (1) instead of being printed in the A.P.I. *Quarterly* as hitherto, it has been published in a pamphlet separately, of smaller and therefore of more convenient size; and (2) it is a joint report based on a co-operative study by the A.P.I. Reserves Committee and the Committee on Natural Gas Reserves of the American Gas Association, thereby making it possible to enlarge the scope of the data. Whereas, previously, it referred solely to estimates of crude oil and certain classes of condensates, it includes for the year ending December 31, 1946, estimates of crude oil, all classes of condensates (natural-gas liquids), and natural gas. In the year 1948, this co-operation between the two committees will continue, so that the annual report bringing the data to December 31, 1947, to be published early in 1948, will be also as comprehensive in its coverage. The form of publication of the results will be continued in the convenient format of a separate pamphlet. The title also will be similar, namely, "Proved Reserves of Crude Oil, Natural Gas Liquids, and Natural Gas."

This report is obviously of great interest to all members of the A.A.P.G., and it is the purpose of this notice to call the attention of the members to the advisability of having their names put on the mailing list for this pamphlet by making an early request, and in any case prior to the publication date, from the American Petroleum Institute, 50 West 50th Street, New York City 20, N.Y.

This report is, of course, of special interest to the members of the Association because the committee which compiles the figures is under the chairmanship of F. H. Lahee, past-president of the Association, and in the various states many of the committee members who prepare the basic data, are also members of the Association.

[1] Chief geophysicist, Gulf Oil Corporation.

RECENT PUBLICATIONS

ARGENTINA

*"Upper Limit of the Jurassic System," by Armando F. Leanza. *Bull. Geol. Soc. America*, Vol. 58, No. 9 (New York, September, 1947), pp. 833–42.

*"Perspectivas Petroleras de la Province de Salta" (Petroleum in Salta, Argentina), by Carlos M. Martinez Eder. *Y.P.F. Bol. Inform. Petroleras*, Vol. 24, No. 275 (Buenos Aires, July, 1947), pp. 10–30; 20 photographs, 4 figs.

CALIFORNIA

*"Trico Gas Field," by William C. Bailey and Ralph M. Barger. *California Oil Fields*, Vol. 32, No. 2 (San Francisco, July–December, 1946; published, 1947), pp. 3–7; 3 pls.

*"West Newport Oil Field," by Charles H. Corwin. *Ibid.*, pp. 8–14; 5 pls.

CANADA

*"A New Field for Canada," by John Ness. *Petrol. Engineer*, Vol. 19, No. 1 (Dallas, Texas, October, 1947), pp. 111–16; 5 photographs.

*"Canada, 1947," by Floyd K. Beach. *Ibid.*, pp. 68–90; 10 photographs, 4 figs.

ENGLAND

*"The Geology of the Silurian Rocks West and North of the Carneddau Range, Radnorshire," by O. T. Jones. *Quar. Jour. Geol. Soc. London*, Vol. 103, No. 409 (August 20, 1947), pp. 1–36; 9 figs., 1 pl. in colors. Geological Society of London, Burlington House, Piccadilly, W. I. London. Price, 10s.

FLORIDA

*"Internal Structure of Some Floridian Foraminifera," by W. Storrs Cole. *Bulletins Amer. Paleon.*, Vol. 31, No. 126 (Paleontological Research Institution, Ithaca, New York, October 8, 1947). 30 pp., 5 pls., 1 text fig., 1 table.

FRANCE

*"L'anticlinal de la Fontaine salée a Sougraine (Aude). Utilization of Aerial Photography" (Fontaine Saline Anticline), by J. P. Destombes. *Bull. Soc. Géol. France*, Ser. 5, Vol. 16, Nos. 4-5-6 (1946), pp. 371–84, geologic map. Published by Société Geol. de France, 28 rue Serpente, Paris VI, France (May, 1947).

*Stratigraphie du Crétacé superieur et de l'Éocene inférieur dans la Chalosse de Montfort (Landes)" (Upper Cretaceous and Lower Eocene in Chalosse de Montfort Department of Landes), by J. Cuvillier and J. Dupouy-Camet. *Ibid.*, pp. 385–97; 2 figs. Contains sketch map of Louer anticline.

GENERAL

*"The Resistivity Curves (Electric Logging)," by Sylvain J. Pirson. *Oil and Gas Jour.*, Vol. 46, No. 25 (Tulsa, October 25, 1947), pp. 94–97; 10 figs.

Principles of Field and Mining Geology, by J. Donald Forrester. 647 pp. 5.625×8.625 inches. John Wiley and Sons, Inc., 440 Fourth Avenue, New York (1946).

*"Bibliography and Index of Publications Relating to Ground Water Prepared by the Geological Survey and Cooperating Agencies," by Gerald A. Waring and Oscar E. Meinzer *U. S. Geol. Survey Water-Supply Paper 992* (1947). 412 pp. For sale by Supt. Documents, Govt. Printing Office, Washington 25, D. C. Price, $1.00.

"Petroleum Development and Technology, 1947," by the Petroleum Division. *Trans. Amer. Inst. Min. Met. Eng.*, Vol. 170 (1947). 279 pp. Papers and discussions presented before the Division at meetings held at Chicago, February 25–28, 1946; Galveston, October 3–5, 1946; Los Angeles, October, 24–25, 1946; and New York, March 19–22, 1947. Published by the Institute, 29 West 39th Street, New York 18, N. Y.

**Plane Table Notebook with Additional Sheets for Field Notes*, by Kenneth K. Landes. 2d ed. (1947). Booklet of 15 pp. (4×6.25 inches) in pocket. Overall size, 4.875×8 inches. "Abbreviated Rules" on inside front cover are handy for beginners and others. George Wahr Publishing Company, Ann Arbor, Michigan. Price, $2.00.

Geophysical Abstracts. The United States Geological Survey has resumed publication

of the *Geophysical Abstracts* after a 4-year interval, during which they were issued by the United States Bureau of Mines. Published quarterly. The bulletin covers world literature on geophysics contained in periodicals, books, and patents. It deals with exploration by gravitational, magnetic, seismic, electrical, radioactive, geothermal, and geochemical methods and with underlying geophysical theory and related subjects. Copies may be purchased singly or by annual subscription from the Superintendent of Documents, Government Printing Office, Washington 25, D. C. For subscription, the Superintendent of Documents will accept a deposit of $5.00 in payment for subsequent issues. When this fund is near depletion the subscriber will be notified. The deposit may also be used to cover purchase of any other publication from the Superintendent of Documents.

**Oil and Petroleum Year Book* (1947), compiled by Walter E. Skinner. International standard reference book on the oil industry. Particulars about 625 companies—producers, refiners, transporters, finance, and oil dealers—arranged in alphabetical order. American and foreign countries. 390 pp., demy 8vo, bound in red cloth. Obtainable from Walter E. Skinner, 20 Copthall Avenue, London E. C. 2, England. Price, 16s.; $4.00; postpaid.

Oil and Gas Field Development in United States, 1946, by National Oil Scouts and Landmen's Association, Hugh J. Roberts, editor in chief, and E. J. Raisch, assistant editor. Year Book, 1947 (Review of 1946), Vol. 17. Annual review of geological and geophysical prospecting, land and leasing activities, wildcat exploration, proved field development, oil and gas production, pipe-line and refinery statistics. 943 pp., illus. Outside dimensions, 8×11 inches; cloth. National Oil Scouts and Landmen's Association, Austin, Texas.

*"Oil Exploration Risks in New Territory," by T. Orchard Lisle. *Oil Forum*, Vol. 1, No. 10 (New York, November, 1947), pp. 285–90; 6 photographs.

*"Flysch and Molasse," by A. J. Eardley and Max G. White. *Bull. Geol. Soc. America*, Vol. 58, No. 11 (New York, November, 1947), pp. 979–90; 1 pl., 1 fig.

GULF COAST

*"Recent Changes in Sedimentation in the Gulf of Mexico," by Parker D. Trask, Fred B. Phleger, Jr., and Henry C. Stetson. *Science*, Vol. 106, No. 2759 (Washington, D. C., November 14, 1947), pp. 460–61.

LOUISIANA

*"Ground-Water Conditions in the Monroe Area, Louisiana," by P. H. Jones and C. N. Holmes. *Louisiana Geol. Survey Bull. 24* (Baton-Rouge, 1947). 47 pp., 4 pls., 4 tables.

MARYLAND

*"Oölite Deformation in the South Mountain Fold, Maryland," by Ernst Cloos. *Bull. Geol. Soc. America*, Vol. 58, No. 9 (New York, September, 1947), pp. 843–918; 13 pls., 21 figs.

OKLAHOMA

*"Anadarko Basin: Geology and Oil Possibilities. Part 3, Geologic History of the Basin," by Robert R. Wheeler. *World Oil*, Vol. 127, No. 7 (Houston, November, 1947), pp. 152–64, Figs. 9–11.

*"Geochemical Survey Data Forecast Major Field [West Edmond]," by Allen Bronston. *Ibid.*, pp. 112–14; 10 figs.

PERU

*"Estudios Tectonicos en la Region del Campo Petrolifero de Pirin lado NW del Lago Titicaca" (Tectonics in the Region of the Pirin Oil Field, on the Northwest Side of Lake Titicaca), by Arnold Heim. *Bol. Dir. Minas y Petroleo*, Vol. 26, No. 79 (Lima, Peru, September, 1947), pp. 1–47; 12 pls., 14 figs.

*"Croquis Tectonico de Campo Petrolifero de Ganso Azul, Rio Pachitea, Peru" (Tectonis of the Ganso Azul Oil Field, Rio Pachitea, Peru), by Arnold Heim. *Ibid.*, pp. 51–62; 5 pls.

PUERTO RICO

*"Geology and Ground-Water Resources of Puerto Rico," by C. L. McGuinness. *Econ. Geol.*, Vol. 42, No. 6 (Urbana, Illinois, September–October, 1947), pp. 563–71; 10 figs.

UTAH

"Stratigraphy of the Wasatch Mountains in the Vicinity of Provo, Utah," by A. A. Baker. *U. S. Geol. Survey Prelim. Chart 30*, Oil and Gas Inves. Ser. (November, 1947). Chart 39×52 inches. Scale, 1 inch equals 500 feet. Obtainable from Director, Geological Survey, Washington 25, D. C. Price, $0.50.

VIRGINIA

*"Rose Hill—First Production in Virginia—First East of Appalachian Plateau," by Ralph L. Miller. *Oil and Gas Jour.*, Vol. 46, No. 27 (Tulsa, November 8, 1947), pp. 78–81; 2 figs.

WESTERN EUROPE

*"Recherches Granulométriques aux Pays-Bas" (Granulometric Research), by D. J. Doeglas. *La Geologie des Terrains Récents dans l'Ouest de l'Europe*, pp. 125–42; 16 figs. In French. Pp. 137–42, discussion by Nils Hörner, in English. Published by M. Hayez, imprimeur de l'Acadamie Royal de Belgique, Rue de Louvain, 112, Bruxelles (1947).

**De Ontioikkeling van de Sedimentpetrologie* (Development of Sedimentary Petrology), by J. Doeglas. 17 pp. In Dutch. H. Veenman and Zonen, Wageningen, Holland (1947).

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 31, NO. 12 (DECEMBER, 1947), PP. 2222-2246, 2 FIGS.

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RAYMOND C. MOORE	TOM MCGLOTHLIN	ROBERT O. VERNON	WAYNE V. JONES
	GROVER E. MURRAY	L. E. WORKMAN	W. ARMSTRONG PRICE
			H. A. TOURTELOT

SUB-COMMITTEE ON CENOZOIC

GROVER E. MURRAY (1949), *chairman*, Magnolia Petroleum Company, Jackson, Mississippi

ROBERT O. VERNON (Atlantic Coast)
ROLLIN ECKIS (Pacific Coast)
TOM MCGLOTHLIN (Eastern Gulf Coast)
PHILIP H. JENNINGS (Western Gulf Coast)
HARRY A. TOURTELOT (Rocky Mts. and Great Plains)

SUB-COMMITTEE ON MESOZOIC

G. D. THOMAS (1949), *chairman*, Shell Oil Company, Inc., Shreveport, Louisiana

R. T. HAZZARD (Gulf Coast)
ROSS L. HEATON (Rocky Mts. and Great Plains)
HORACE G. RICHARDS (Atlantic Coast)

SUB-COMMITTEE ON PALEOZOIC

ROBERT H. DOTT (1948), *chairman*, Oklahoma Geological Survey, Norman, Oklahoma

H. D. THOMAS (Rocky Mts. and Great Plains)
STUART K. CLARK (Mid-Continent)
L. E. WORKMAN (Eastern Interior)
W. J. HILSEWECK (Southwestern U. S. A.)
J. H. C. MARTENS (Appalachian Region)

ADVISORY AND SPECIAL PROJECTS SUB-COMMITTEE

JOHN G. BARTRAM (1948), *chairman*, Stanolind Oil and Gas Company, Tulsa, Oklahoma

ARTHUR E. BRAINERD	E. FLOYD MILLER	RAYMOND C. MOORE
WAYNE V. JONES	HUGH D. MISER	W. ARMSTRONG PRICE
		GAYLE SCOTT

COMMITTEE ON APPLICATIONS OF GEOLOGY

KENNETH K. LANDES (1948), *chairman*, University of Michigan, Ann Arbor, Michigan

1948	1949	1950
ROBERT I. DICKEY	E. M. BAYSINGER	DON L. CARROLL
CHARLES R. FETTKE	CHARLES J. DEEGAN	STANLEY G. ELDER
OLAF P. JENKINS	L. B. HERRING	LEO R. FORTIER
NICHOLAS A. ROSE	R. A. STEHR	THOMAS A. HENDRICKS
		W. T. NIGHTINGALE
		W. T. SCHNEIDER

MEDAL AWARD COMMITTEE

CARROLL E. DOBBIN, *chairman*, U. S. Geological Survey, Denver, Colorado
JAMES A. WATERS, *ex officio*, president of S.E.P.M.
CECIL H. GREEN, *ex officio*, president of S.E.G.

1948	1949	1950
A. RODGER DENISON	RUSSELL S. MCFARLAND	FRANK R. CLARK
VIRGIL B. COLE	RAYMOND F. BAKER	ALFRED H. BELL
J. EDMUND EATON	W. C. SPOONER	A. E. BRAINERD

COMMITTEE ON STATISTICS OF EXPLORATORY DRILLING

F. H. LAHEE (1950), *chairman*, Sun Oil Company, Box 2880, Dallas, Texas
PAUL WEAVER (1948), *vice-chairman*, Gulf Oil Corporation, Box 2100, Houston, Texas

1948	1949	1950
KENNETH COTTINGHAM	STANLEY G. ELDER	A. H. BELL
RALPH E. ESAREY	COLEMAN D. HUNTER	S. A. BERTHIAUME
FENTON H. FINN	ROBERT C. LAFFERTY, JR.	G. P. CRAWFORD
JOHN W. INKSTER	D. J. MUNROE	R. J. CULLEN
GRAHAM B. MOODY	T. F. PETTY	W. S. MCCABE
CHARLES H. ROW	GLENN C. SLEIGHT	E. L. REED, JR.
	PAUL H. UMBACH	R. M. WILSON
	C. W. WILSON	

DISTINGUISHED LECTURE COMMITTEE

FRED H. MOORE (1949), *chairman*, Magnolia Petroleum Company, Roswell, New Mexico

1948	1949	1950
EVERETT F. STRATTON	HUGH R. BRANKSTONE	W. J. HILSEWECK
CARROLL M. WAGNER	JOHN L. FERGUSON	H. T. MORLEY

SPECIAL COMMITTEES

COMMITTEE ON BOY SCOUTS LITERATURE

FRANK GOUIN, *chairman*, Box 208, Duncan, Oklahoma

A. C. BACE	C. L. COOPER	R. C. SPIVEY
MAX W. BALL	CAREY CRONEIS	W. T. THOM, JR.
HAL P. BYBEE	E. C. DAPPLES	RUSSELL M. TRIPP
DON L. CARROLL	G. W. PIRTLE	MARTIN VAN COUVERING

EDUCATION COMMITTEE

ROY R. MORSE, *chairman*, Shell Oil Company, Box 2099, Houston, Texas

STUART K. CLARK	RONALD K. DEFORD	THERON WASSON
MORGAN J. DAVIS	HENRY V. HOWE	

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

CONSTITUTION[1]

ARTICLE I. NAME

This Association shall be called "The American Association of Petroleum Geologists," incorporated under the laws of Colorado.

ARTICLE II. OBJECT

The object of this Association is to promote the science of geology, especially as it relates to petroleum and natural gas; to promote the technology of petroleum and natural gas and to encourage improvements in the methods of exploring for and exploiting these substances; to foster the spirit of scientific research amongst its members; to disseminate facts relating to the geology and technology of petroleum and natural gas.

ARTICLE III. MEMBERSHIP

Members

SECTION 1. Any person engaged in the work of petroleum geology or in research pertaining to petroleum geology or technology is eligible to active membership, provided he is a graduate of an institution of collegiate standing, in which institution he has done his major work in geology, or in sciences fundamental to petroleum geology, and in addition has had the equivalent of three years' experience in petroleum geology or in the application of these other sciences to petroleum geology or to research in petroleum geology or technology; and provided further that in the case of an applicant for membership who has not had the required collegiate or university training, but whose standing in the profession is well recognized, he shall be admitted to membership when his application shall have been favorably and unanimously acted upon by the executive committee; and provided further that these requirements shall not be construed to exclude teachers and research workers in recognized institutions, whose work is of such character as in the opinion of the executive committee shall qualify them for membership.

Active members alone shall be known as members.

Life Members

SECTION 2. The executive committee may grant life memberhsip to members who have paid their dues and are otherwise qualified.

Associates

SECTION 3. Any person having completed as much as thirty hours of geology (an hour shall here be interpreted as meaning as much as sixteen recitation or lecture periods of one hour each, or the equivalent in laboratory) in a reputable institution of collegiate or university standing, or who has done field work equivalent to this, is eligible to associate membership, provided at the time of his application for membership he shall be engaged in geological studies in an institution of collegiate or university standing, or shall be engaged in petroleum geology; and any person who is a graduate of an institution of collegiate standing in which he has done his major work in sciences fundamental to petroleum geology or petroleum technology, and who has the equivalent of one year's experience in the application of his science to the study of petroleum geology, shall be eligible to associate member-

[1] The constitution and by-laws were adopted 1918, and amended 1921, 1922, 1923, 1925, 1927 1928, 1929, 1930, 1932, 1933, 1935, 1936, 1939, 1940, 1942, 1943, 1944, 1945, and 1946.

ship, provided at the time of his application for membership he shall be engaged in investigations in the broader subject of petroleum geology and technology.

Associate members shall be known as associates.

Associates shall enjoy all the privileges of membership in the Association, save that they shall not hold office, sign applications for membership, or vote; neither shall they have the privilege of advertising their affiliation with the Association in professional cards or professional reports or otherwise.

The executive committee may advance to active membership, without the formality of application for such change, those associates who have, subsequent to election, fulfilled the requirements for active membership.

Election to Membership

SECTION 4. Every candidate for admission as a member or associate shall submit a formal application on an application form authorized by the executive committee, signed by him, and endorsed by not less than three members who are in good standing, stating his training and experience and such other facts as the executive committee shall from time to time prescribe. Provided the executive committee, after due consideration, shall judge that the applicant's qualifications meet the requirements of the constitution, they shall cause to be published in the *Bulletin* the applicant's name and the names of his sponsors. If after at least thirty days have elapsed since such publication, no reason is presented why the applicant should not be admitted, he shall be deemed eligible to membership or to associate membership, as the case may be, and shall be notified of his election.

With the notice of election shall be included a copy of the constitution and by-laws of the Association.

SECTION 5. An applicant for membership, on being notified of his election in writing, shall pay full membership dues for the current year and on making such payment shall be entitled to receive the entire *Bulletin* for that year. Unless payment of dues is made within thirty (30) days by those living within the continental United States and within ninety (90) days by those living elsewhere, after notice of election has been mailed, the executive committee may rescind the election of the applicant. Upon payment of dues, each applicant for membership shall be furnished with a membership card for the current year, and until such written notice and card are received, he shall in no way be considered a member of the Association.

Honorary Members

SECTION 6. The executive committee may from time to time elect as honorary members persons who have contributed distinguished service to the cause of petroleum geology. Honorary members shall not be required to pay dues.

SECTION 7. Each member and associate shall be guided by the highest standards of business ethics, personal honor, and professional conduct.

SECTION 8. Any member or associate who, after due investigation, is found guilty of violating any of the standards of conduct prescribed in Section 7 of this Article, may be admonished, suspended, allowed to resign, or dropped from membership in accordance with the procedure provided in the by-laws.

ARTICLE IV. OFFICERS AND THEIR DUTIES

OFFICERS

SECTION 1. The officers of the Association shall be a president, a vice-president, a secretary-treasurer, and an editor. These, together with the past-president, shall constitute the executive committee and managers of the Association.

SECTION 2. The officers shall be elected annually from the Association at large by

means of secret mailed ballot in the following manner. The nominating committee shall nominate one or more candidates for each office, and its nominations shall be published in the September *Bulletin*. Additional nominations may be made by written petition of fifty, or more, members in good standing received at Association headquarters not later than November 15. The executive committee shall then prepare a printed ballot, listing the candidates for each office, and one ballot shall be mailed to each member as soon after November 15 as possible. Ballots returned to Association headquarters on or before January 31 shall be placed as received in a locked ballot box and promptly after January 31 the ballot committee shall open the ballot box and count the ballots. Ballots of delinquent members shall not be counted. A majority of all votes cast for an office is necessary for election. If there are three or more nominees for any office, a preferential form of ballot shall be used. In case of a tie vote, the executive committee shall cast one additional deciding vote. Each candidate, when voted for as a candidate for the particular office for which he is nominated, shall be thereby automatically voted for as a candidate for the executive committee for one year, except that candidates for the presidency shall be automatically voted for as candidates for the executive committee for two years.

SECTION 3. No one shall hold the office of president for two consecutive years and no one shall hold any other office for more than two consecutive years except the editor who shall not hold office for more than six consecutive years.

Duties of Officers

SECTION 4. The president shall be the presiding officer at all meetings of the Association, shall take cognizance of the acts of the Association and of its officers, shall appoint such committees as are required for the purposes of the Association, except the nominating committee, and shall delegate members to represent the Association. He may, at his option, serve on, and may be chairman of, any committee, except the nominating committee.

SECTION 5. The vice-president shall assume the office of president in case of a vacancy from any cause in that office and shall assume the duties of president in case of the absense or disability of the latter. If the past-president shall for any reason be unable to serve as a member of the executive committee, the president shall fill the vacancy by the appointment of the next available preceding past-president.

A vacancy or disability occurring in the office of vice-president, secretary-treasurer, or editor shall be filled by majority vote of the executive committee, either for the unexpired term or for the period of disability, as the committee may decide. In the case of a tie, the president shall cast the deciding vote.

SECTION 6. The secretary-treasurer shall assume the duties of president in case of the absence of both the president and vice-president. He shall have charge of the financial affairs of the Association and shall annually submit reports as secretary-treasurer covering the fiscal year. He shall receive all funds of the Association, and, under the direction of the executive committee, shall disburse all funds of the Association. He shall cause an audit to be prepared annually by a public accountant at the expense of the Association. He shall give a bond, and shall cause to be bonded all employees to whom authority may be delegated to handle Association funds. The amount of such bonds shall be set by the executive committee and the expense shall be borne by the Association. The funds of the Association shall be disbursed by check as authorized by the executive committee.

SECTION 7. The editor shall be in charge of editorial business, shall submit an annual report of such business, shall have authority to solicit papers and material for the *Bulletin* and for special publications, and, with the approval of the executive committee, may accept or reject material offered for publication. He may appoint associate, regional, and special editors.

SECTION 8. The officers shall assume the duties of their respective offices immediately after the annual meeting, which follows their election.

ARTICLE V. EXECUTIVE COMMITTEE—MEETINGS AND DUTIES

Executive Committee

SECTION 1. The executive committee shall consist of the president, past-president, vice-president, secretary-treasurer, and editor.

Meetings and Duties

SECTION 2. The executive committee shall meet immediately preceding the annual meeting and at the call of the president may hold meetings when and where thought advisable, to conduct the affairs of the Association. A joint meeting of the outgoing and incoming executive committees shall be held immediately after the close of the annual Association business meeting. Members of the executive committee may vote by proxy on matters which require a unanimous vote.

SECTION 3. The executive committee shall consider all nominations for membership and pass on the qualifications of the applicants; shall have control and management of the affairs and funds of the Association; shall determine the manner of publication and pass on the material presented for publication; shall designate the place of the annual meeting; shall appoint the nominating committee and its chairman; and shall be in charge of the annual election of officers and decide eligibility and other questions pertaining to the election. They are empowered to establish a business headquarters for the Association, and to employ such persons as are needed to conduct the business of the Association. They are empowered to accept, create, and maintain special funds for publication, research, and other purposes. They are empowered to make investments of both general and special funds of the Association. Trust funds may be created, giving to the trustees appointed for such purpose, such direction as to investments as seems desirable to the executive committee to accomplish any of its objects and purposes, but no such trust funds shall be created unless they are revocable upon ninety (90) days' notice.

ARTICLE VI. MEETINGS

The Association shall hold at least one stated meeting each year, which shall be the annual meeting. This meeting shall be held in March or April at a time and place designated by the executive committee. At this meeting the election of members shall be announced, the proceedings of the preceding meeting shall be read, Association business shall be transacted, scientific papers shall be read and discussed and officers for the ensuing year shall be announced.

ARTICLE VII. AMENDMENTS

Amendments to this constitution may be proposed by a resolution of the executive committee, by a constitutional committee appointed by the president, or in writing by any ten members of the Association. All such resolutions or proposals must be submitted at the annual meeting of the business committee of the Association as provided in the by-laws, and only the business committee shall make recommendations concerning proposed constitutional changes at the annual Association business meeting. If such recommendations by the business committee shall be favorably acted on at the annual Association business meeting, the secretary-treasurer shall arrange for a ballot of the membership by mail within thirty (30) days after said annual Association business meeting, and a majority vote of the ballots received within ninety (90) days of their mailing shall be sufficient to amend. The legality of all amendments must be determined by the executive committee prior to balloting.

BY-LAWS

ARTICLE I. DUES

SECTION 1. The fiscal year of the Association shall correspond with the calendar year.

SECTION 2. The annual dues of members of the Association shall be ten dollars ($10.00). The annual dues of associates for not to exceed three years after election shall be six dollars ($6.00); for the second three-year period eight dollars ($8.00); thereafter, the annual dues of such associates shall be ten dollars ($10.00). The annual dues are payable in advance on the first day of each calendar year. A bill shall be mailed to each member and associate before December first of each year, stating the amount of the annual dues and the penalty and conditions for default in payment. Members or associates who shall fail to pay their annual dues by January first shall not receive copies of the January *Bulletin* or succeeding *Bulletins*, nor shall they be privileged to buy Association special publications at prices made to the membership, until such arrears are met.

During any period in which the United States is actually engaged in war and for a period of one year thereafter, the executive committee may at its discretion suspend, reduce, or waive annual dues to members or associate members serving in the armed forces of the United States or any allied country, without otherwise affecting their membership, except that they shall not receive the *Bulletin* during a period for which no dues are paid.

SECTION 3. On the payment of two hundred dollars ($200.00) any member in good standing shall be declared a life member and thereafter shall not be required to pay annual dues. The funds derived from this source shall be placed in a permanent investment, the income from which shall be devoted to the same purposes as the regular dues.

ARTICLE II. RESIGNATION—SUSPENSION—EXPULSION

SECTION 1. Any member or associate may resign from the Association at any time. Such resignation shall be in writing and shall be accepted by the executive committee, subject to the payment of all outstanding dues and obligations of the resigning member or associate.

SECTION 2. Any member or associate who is more than a year delinquent (in arears) in payment of dues shall be suspended from the Association. Any delinquent or suspended member or associate, at his own option, may request in writing that he be dropped from the Association and such a request shall be granted by the executive committee. Any member or associate more than two years in arrears shall be dropped from the Association. The time of payment of delinquent dues for either one year or two years may be extended by unanimous vote of the executive committee.

SECTION 3. Any member or associate who resigns or is dropped under the provisions of Sections 1 and 2 of this article ceases to have any rights in the Association and ceases incur further indebtedness to the Association.

SECTION 4. Any person who has ceased to be a member or associate under Section 1 or Section 2 of this article may be reinstated by unanimous vote of the executive committee subject to the payment of any outstanding dues and obligations which were incurred, prior to the date when he ceased to be a member or associate of the Association.

In the case of any member or associate who has been dropped between the dates of January 1, 1931, and January 1, 1936, for non-payment of dues and who shall apply for reinstatement, the executive committee is authorized, at its discretion, to accept the resignation of such member or associate, effective at any date during such period of delinquency, provided, the member shall pay all indebtedness to the Association incurred prior to the date of such resignation including a proper proportion of annual dues as shall be fixed by the executive committee. Such member or associate shall not be entitled to receive the *Bulletin* for any period subsequent to the date when his resignation became effective and prior to his reinstatement.

SECTION 5. Charges of misconduct in violation of Section 7 of Article III of the constitution shall first be submitted in writing to the president of the Association by a member in good standing, in confidence, with a full statement of the evidence on which the charges are based. If in his judgment they merit further consideration, he shall appoint a committee to consist of three past-presidents of the Association, which shall examine into the charges. If in the judgment of said committee, the facts warrant, it shall prepare and file with the executive committee formal charges against the accused member or associate. As soon as may be after the receipt of such charges the executive committee shall fix a date and place for hearing thereupon, and shall give to the accused person notice thereof in writing, mailed to him by registered mail at his last-known post-office address not less than thirty (30) days before said date, accompanied by a copy of the charges, and a copy of this article.

SECTION 6. On the day fixed for the hearing, the accused person may appear before the executive committee, either in person or by an accredited representative; hear any witnesses who may be called in support of the charges; and, at this option, cross-examine the same, and hear any documentary evidence, including a statement from himself in writing. At his option, he may by letter waive personal hearing, and request the executive committee to adjudge the matter on the basis of a written statement of his defense, mailed to the committee before the date set for the hearing. After the conclusion of the hearing, or study of written defense submitted in lieu of a personal hearing, the executive committee shall consider and vote to approve or disapprove the charges. If the executive committee shall, by unanimous vote, declare the charges sustained, it may suspend the accused person from membership for a stated period, admonish him, allow him to resign, or expel him. Failure of the accused person to appear either in person or by an accredited representative shall not prevent the executive committee from proceeding with the trial.

SECTION 7. If the accused person shall not appear at the hearing nor waive his right thereto, and shall within three months after the date set for the hearing file with the executive committee an affidavit stating that he had not received notice of the charges against him in time to enable him to present his defense, the executive committee shall fix a date and place for a hearing not less than thirty days nor more than three months from the receipt of such affidavit, and shall immediately notify the accused person by registered mail of such date and place. Upon the rehearing, the proceedings shall be governed by the provisions of Section 6 of this article.

SECTION 8. Resignation of the accused person from membership in the Association, at any stage of the foregoing prescribed proceedings, shall automatically terminate the proceedings.

SECTION 9. The decision of the executive committee in all matters pertaining to the interpretation and execution of the provisions of Sections 5, 6, and 7 of this article shall be final.

ARTICLE III. PUBLICATIONS

SECTION 1. The proceedings of the annual meeting and the papers presented at such meetings shall be published at the discretion of the executive committee in the Association *Bulletin* or in such other form as the executive committee may decide best meets the needs of the membership of the Association.

SECTION 2. The payment of annual dues for any fiscal year entitles the member or associate to receive without further charge a copy of the *Bulletin* of the Association for that year.

SECTION 3. The executive committee may authorize the printing of special publications to be financed by the Association from its general, publication, or special funds and offered for sale to members and associates in good standing at not less than cost of publication and distribution.

ARTICLE IV. REGIONAL SECTIONS, TECHNICAL DIVISIONS, AND AFFILIATED SOCIETIES

SECTION 1. Regional sections of the Association may be established provided the members of such sections are members of the Association and shall perfect an organization and make application to the executive committee. The executive committee shall submit the application to a vote at a regular annual meeting, an affirmative vote of two-thirds of the members present and voting being necessary for the establishment of such a section; and provided that the Association may revoke the charter of any regional section by a vote of two-thirds of the members present and voting at a regular annual meeting.

SECTION 2. Technical divisions may be established, provided the members interested shall perfect an organization and make application to the executive committee. The executive committee shall submit the application to a vote at a regular meeting, an affirmative vote of two-thirds of the membership present and voting being necessary for the establishment of such a division. In like manner, the Association may dissolve a division by an affirmative vote of two-thirds of the members present and voting at any annual meeting. A technical division may have its own officers, and it may have its own constitution and by-laws provided that, in the opinion of the executive committee, these do not conflict with the constitution and by-laws of the Association. The executive committee shall be empowered to make arrangements with the officers of the division for the conduct of the business of the division. A division may admit to affiliate membership in the division specially qualified persons who are not eligible to membership in the Association. Technical divisions may affiliate with other scientific societies, with the approval of the executive committee.

SECTION 3. Subject to the affirmative vote of two-thirds of the membership present and voting at an annual meeting, and with legal advice, the executive committee may arrange for the affiliation with the Association of duly organized groups or societies, which by objects, aims, constitutions, by-laws, or practice are developing the study of geology or petroleum technology. In like manner and with like advice, the executive committee may arrange conditions for dissolution of such affiliations. Affiliation with the Association need not prevent affiliation with other scientific societies. Members of affiliated societies who are not members of the Association, shall not have the privilege of advertising their affiliation with the Association on professional cards or othersiwe.

ARTICLE V. DISTRICT REPRESENTATIVES

The executive committee shall cause to be elected district representatives from districts which it shall define by a local geographic grouping of the membership. Such districts shall be redesignated and redefined by the executive committee as often as seems advisable. Each district shall be entitled to one representative for each seventy-five members, but this shall not deprive any designated district of at least one representative. The representatives so apportioned shall be chosen from the membership of the district by a written ballot arranged by the executive committee. They shall hold office for two years, their term of office expiring at the close of the annual meeting.

ARTICLE VI. COMMITTEES

Appointment and Tenure

SECTION 1. There shall be the following standing committees: business committee; research committee; committee on geologic names and correlations; committee on applications of geology; committee for publication; finance committee; committee on statistics of exploratory drilling; trustees of revolving publication fund; trustees of research fund; medal award committee; and distinguished lecture committee.

The president shall appoint all standing committees except the business committee

and the medal award committee, for which provision is hereafter made. Members of all committees except the business committee shall serve for a three-year term, but in rotation, with one-third of the members being appointed each year. The president shall designate the chairmen, annually, shall have power to fill vacancies, and shall notify the members of the committees of their appointment. The president may designate one or more vice-chairmen annually.

In addition to the aforesaid standing committees, the executive committee shall appoint annually a nominating committee and its chairman, the president shall appoint annually a ballot committee, and annually or semiannually a resolutions committee, and such special committees as the executive committee may authorize. Special committees shall be appointed for a term of one year. The president shall designate the chairmen of such committees.

Business Committee

SECTION 2. The business committee shall act as a council and advisory board to the executive committee and the Association. This committee shall consist of the executive committee, not more than five members at large appointed annually by the president, two members elected by and from each technical division, and the district representatives. The president shall also appoint annually a chairman and a vice-chairman, but neither of these need be one of those otherwise constituting the business committee. The secretary-treasurer shall act as secretary of the business committee. If a district or technical representative is unable to be present at any meeting of the committee he may designate an alternate, who, in the case of a district representative, may or may not be a resident of the district he is asked to represent, and the alternate, on presentation of such a designation in writing, shall have the same powers and privileges as a regularly chosen representative. The business committee shall meet the day before the annual meeting at which all proposed changes in the constitution or by-laws shall be considered, all old and new business shall be discussed, and recommendations shall be voted for presentation at the annual meeting.

Research Committee

SECTION 3. The purpose of the research committee is the advancement of research, particularly with in the field of petroleum geology. The committee shall consist of twenty-four members unless a different number is authorized by the executive committee.

Committee on Geologic Names and Correlations

SECTION 4. The purpose of the committee on geologic names and correlations is to lend assistance to authors on problems on stratigraphy and nomenclature and to advise the editor and executive committee in regard to the propriety of the use of stratigraphic names and correlations in papers submitted for publication by the Association. The committee shall consist of fifteen members unless a different number is authorized by the executive committee.

Committee on Applications of Geology

SECTION 5. The object of the committee on applications of geology is to advise and promote ways and means for informing the general public on all phases of geology particularly on the natural occurrence of oil and gas underground, the methods of searching for these substances, and the methods of exploiting them. The committee shall consist of twelve members unless a different number is authorized by the executive committee.

Committee for Publication

SECTION 6. The purpose of the committee for publication is to assist in securing desirable manuscripts for publication in the *Bulletin* or other publications of the Association.

The committee may also assist in securing papers for delivery at the annual meetings. The committee shall consist of twenty-four members unless a different number is authorized by the executive committee.

Finance Committee

SECTION 7. The finance committee shall act as financial advisers to the executive committee. The committee shall consist of three members. If a member of the finance committee should be elected to the executive committee he shall resign from the finance committee and the president shall appoint a member of the Association to complete his unexpired term.

Trustees of Revolving Publication Fund

SECTION 8. Before any publication project shall be undertaken with the use of the revolving publication fund the approval of the trustees and the executive committee must be secured. There shall be three trustees. If a trustee should be elected to the executive committee he shall resign as a trusteee and the president shall appoit a member of the Association to complete his unexpired term.

Trustees of Research Fund

SECTION 9. Before any research work may be undertaken with the use of money from the research fund, the approval of the trustees and the executive committee shall be secured. There shall be three trustees. If a trustee shall be elected to the executive committee he shall resign as a trustee and the president shall appoint a member of the Association to complete his unexpired term.

Resolutions Committee

SECTION 10. The resolutions committee shall be charged with the duty of presenting at the annual and semi-annual meetings resolutions expressing the Association's appreciation and thanks to those who have worked and contributed to the success of the meetings.

Medal Award Committee

SECTION 11. The purpose of the committee shall be to choose recipients for all medals or other awards which may be established by the executive committee. The committee shall consist of nine members and three ex-officio members. The nine members of the original committee shall be appointed by the president, three of whom shall serve for three years, three for two years, and three for one year. One of each of the groups appointed for the different lengths of time shall be a former president of the Association. Each incoming president shall thereafter appoint three members of the committee to serve for three years, one of which shall be a former president of the Association. Vacancies on the committee due to resignation or other causes shall be immediately filled by the president. The ex-officio members shall be: (1) the president of the Association, (2) the president of the Society of Exploration Geophysicists, (3) the president of the Society of Economic Paleontologists and Mineralogists. The president of the Association shall be the chairman of the committee, unless he shall, at his election, name a chairman to serve for one year.

Committee on Statistics of Exploratory Drilling

SECTION 12. The function of the committee on statistics of exploratory drilling shall be to assemble and compile statistics on the methods used to locate exploratory wells and on the results of exploratory drilling for oil and gas, and annually to submit for publication in the *Bulletin* a report summarizing and analyzing these data. This committee shall consist of twenty-four members unless a different number is authorized by the executive committee.

Distinguished Lecture Committee

SECTION 13. The purpose of the distinguished lecture committee is to arrange, conduct, and manage a series of self-sustaining, non-profit lecture tours among affiliated societies and Association sections by outstanding speakers on timely subjects. The committee shall consist of seven members unless a different number is authorized by the executive committee.

Nominating Committee

SECTION 14. The purpose of the nominating committee is to nominate candidates for the Association offices as provided in the constitution. The committee shall consist of a chairman and four other members appointed by the executive committee to serve one year. At least two members of the nominating committees shall be past officers of the Association.

Ballot Committee

SECTION 15. The function of the ballot committee is to count the ballots received in the regular annual election and to report the final results to the president. A preferential form of ballot shall be counted in the following manner. The ballot committee shall count first-choice votes only. If no candidate receives a majority, the candidate with the fewest votes shall be eliminated and the second choice on his ballots shall be counted as first choice for the remaining candidates. The committee shall continue this procedure until one candidate has a majority.

ARTICLE VII. AMENDMENTS

These by-laws may be amended by vote of three-fourths of the members present and voting at any annual meeting, provided that such changes shall have been recommended to the meeting by the business committee and provided that their legality shall be determined by the executive committee prior to publication.

MEMBERSHIP APPLICATIONS APPROVED FOR PUBLICATION

The executive committee has approved for publication the names of the following candidates for membership in the Association. This does not constitute an election but places the names before the membership at large. If any member has information bearing on the qualifications of these nominees, he should send it promptly to the Executive Committee, Box 979, Tulsa 1, Oklahoma. (Names of sponsors are placed beneath the name of each nominee.)

FOR ACTIVE MEMBERSHIP

Ibrahim Enver Altinli, Pasadena, Calif.
John P. Buwalda, Beno Gutenberg, Ian Campbell
George Thomas Becker, Bogota, Colombia, S. A.
C. H. Dresbach, H. D. Hedberg, Augustin Pyre
Laurence Lowell Harp, Houston, Tex.
J. E. La Rue, D. P. Carlton, F. H. McGowan
Frederick C. Hodges, Bakersfield, Calif.
A. B. Dooley, Drexler Dana, E. H. Vallat
William Howard Hough, Houston, Tex.
P. B. Leavenworth, H. E. Minor, Marcus A. Hanna
John Allan Legge, Jr., Fairbanks, Alaska
Herbert Hoover, Jr., A. A. Curtice, Wayne H. Denning
Orville Glebe Lundstrom, Dallas, Tex.
Henry J. Morgan, Jr., W. Dow Hamm, O. C. Clifford, Jr.

Stanley Brahame Radack, Caracas, Venezuela, S. A.
Joseph M. Patterson, Joe G. Wilson, Robert S. Breitenstein
William Charles Schmitz, Lafayette, La.
C. B. Claypool, K. V. Schroeder, Max Bornhauser

FOR ASSOCIATE MEMBERSHIP

Curtis Leyrer Amuedo, Baton Rouge, La.
Chalmer J. Roy, Harold N. Fisk, H. V. Howe
John Herman Baade, Moore, Okla.
H. J. Ferber, F. A. Melton, Carl A. Moore
John Malcolm Baird, Houston, Tex.
Samuel S. Goldich, A. P. Wendler, F. A. L. Burt
Thomas Walter Brown, Laramie, Wyo.
Ben H. Parker, F. M. Van Tuyl, William S. Levings
Wallace Harlon Cochrane, Olympia, Wash.
W. Layton Stanton, Charles E. Weaver, W. W. Heathman
Fulton Shirley Gantt, Houston, Tex.
P. B. Leavenworth, H. E. Minor, B. G. Martin
Dwight Charles Gilkison, Houston, Tex.
L. R. Laudon, John Frye, J. M. Jewett
Dorothy Viola Harkness, Los Angeles, Calif.
E. R. Atwill, Max L. Krueger, U. S. Grant
Parrish Richard Heath, Wichita Falls, Tex.
W. I. Robinson, Philip D. Larson, Richard B. Phillips
Richard Charles Klett, Casper, Wyo.
Roland F. Hodder, Willis H. Fenwick, Paul T. Walton
Russell Francis Klinger, Houston, Tex.
M. R. Spahr, William R. Campbell, M. M. Sheets
Rulon Stuart Mahannah, Golden, Colo.
J. Harlan Johnson, W. S. Levings, F. M. Van Tuyl
James Plummer Morgan, Baton Rouge, La.
H. N. Fisk, Richard Joel Russell, H. V. Howe
Herman E. Nichols, Jr., Ardmore, Okla.
M. P. White, C. W. Tomlinson, Carl A. Moore
Burdette Adrian Ogle, Los Angeles, Calif.
Olaf P. Jenkins, Theo H. Crook, William W. Rand
Sam M. Pena, Houston, Tex.
W. Harlan Taylor, C. D. Whitsitt, P. J. Rudolph
Claude Daniel Pressler, Houston, Tex.
M. R. Spahr, William R. Campbell, M. M. Sheets
Junior Lee Reynolds, Sulphur, La.
Chalmer J. Roy, Richard Joel Russell, H. N. Fisk
Janet Elizabeth Rieder, Taft, Calif.
J. D. Bainton, E. H. Burtner, Stanislav J. Kriz
Harold Glen Sehnert, Jr., Evansville, Ind.
Sam H. Stith, Jr., Edward J. Combs, Stanley G. Elder
Lawrence Henry Smith, Algonac, Mich.
L. J. Fulton, Stewart Cronin, F. A. Thurman
Ellick Groce Stevenson, Lawrence, Kan.
Rufus M. Smith, John C. Frye, L. R. Laudon
Patricia Allan Stewart, Bartlesville, Okla.
Warren B. Weeks, Daniel J. Jones, Don B. Gould

Barbara Ann Summerill, Shreveport, La.
G. D. Thomas, G. E. Tash, Charles Nevin
Robert Thomas Trueheart, Jackson, Miss.
L. R. Laudon, John C. Frye, Raymond C. Moore
Thomas Edward Turner, Roswell, N. Mex.
V. E. Peterson, Fred H. Moore, Julian D. Barksdale
James David Vine, Ann Arbor, Mich.
N. W. Bass, K. K. Landes, William G. Pierce
Betty Jeanne Wilkes, Houston, Tex.
Edward J. Hamner, F. W. Rolshausen, Emmett P. Tatum

FOR TRANSFER TO ACTIVE MEMBERSHIP

Maerlant M. Barlow, Oklahoma City, Okla.
W. B. Perry, William T. Thomas, Henry A. Campo
Robert Lowell Benish, Houston, Tex.
Lloyd M. Pyeatt, W. F. Cooke, Jr., Fred L. Smith, Jr.
Donald Thomas Gibson, Tyler, Tex.
Laurence S. Melzer, R. M. Trowbridge, A. C. Christenson
Don Winter Jopling, Dallas, Tex.
Lester L. Logue, Frank K. Fisk, Cecil H. Green
William Albert McMorris, Tulsa, Okla.
Dollie Radler Hall, John L. Ferguson, Andrew Gilmour

EASTERN INTERIOR REGIONAL MEETING
ST. LOUIS, JANUARY 14–15, 1948

GENERAL COMMITTEE

E. E. REHN, *chairman*
Sohio Petroleum Company, Box 537, Mount Vernon, Illinois

PROGRAM: STANLEY G. ELDER
TECHNICAL: CARL BAYS
REGISTRATION: T. E. WALL
PUBLICITY: GENE GADDESS
HOTELS: THEODORE G. GLASS
ENTERTAINMENT: C. E. BREHM
FINANCE: CHARLES A. DOH
EXHIBITS: GIL RAASCH
RECEPTION: HARRY H. NOWLAN

The Eastern Interior regional meeting of the Association will be held at the Jefferson Hotel, St. Louis, Missouri, on January 14 and 15, 1948. It is sponsored by the Illinois Geological Society and the Indiana-Kentucky Geological Society. The technical program will place emphasis on the regional features between the Ozarks and the Appalachians. It is intended to include papers on oil fields, interpretation of electrical logs, geophysical problems, and geological aspects of water flooding. No field trips are being planned.

Entertainment.—An informal smoker will be held Tuesday night, January 13. There is no admission charge.

A semi-formal dinner-dance is arranged for Thursday night, January 15, with music furnished by an excellent orchestra. Admission charge will approximate $4.00 per plate and reservations are essential for planning by the entertainment committee.

Indicate on your hotel reservation if you expect to attend either or both of these events.

Hotel reservations.—Address all requests for reservations to

Housing Bureau, A.A.P.G.
910 Syndicate Trust Building
Saint Louis 1, Missouri.

Reservations should be made prior to December 31, 1947, and should give all information requested on sample form printed herewith. Be sure to indicate your attendance for the smoker and dinner-dance.

Convention headquarters will be the Jefferson Hotel. All hotels are in the downtown district. The Jefferson has reserved 300 rooms; the Statler, 200; the Lenox, 50; the Mark Twain, 50; the Mayfair, 50; the DeSoto, 50. Prices are shown on included break-down.

Each member has been mailed a copy of the announcement and a hotel reservation form, a sample of which is here printed for information.

APPLICATION FOR HOUSING ACCOMMODATIONS ST. LOUIS, MO.

AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS JANUARY 14–15, 1948

For your convenience in making hotel reservations for the coming meeting of the American Association of Petroleum Geologists January 14–15, 1948 in St. Louis, hotels and their rates are listed below. Use the form at the bottom of this page, indicating your first, second and third choice. Because of the limited number of single rooms available, you will stand a much better chance of securing accommodations if your request calls for rooms to be occupied by two or more persons. All reservations must be cleared through the housing bureau. ALL REQUESTS FOR RESERVATIONS MUST GIVE DEFINITE DATE AND HOUR OF ARRIVAL AS WELL AS DEFINITE DATE AND APPROXIMATE HOUR OF DEPARTURE, ALSO NAMES AND ADDRESSES OF ALL PERSONS WHO WILL OCCUPY RESERVATIONS REQUESTED MUST BE INCLUDED.

Hotel	For one person	For two persons		2-Room Suites
		Double Bed	Twin Beds	Parlor & Bedroom
DE SOTO	2.75–7.00	4.00–7.00	6.00–12.00	10.50–12.00
JEFFERSON	3.50–6.00	5.00–7.00	7.00– 8.00	14.00–22.00
LENOX	3.25–6.00	5.00–6.50	6.00– 8.00	11.00
MARK TWAIN	3.00–3.50	4.50–5.00	5.00– 5.50	
MAYFAIR	3.25–7.00	4.50–8.00	6.00– 8.00	11.00 & Up
STATLER	3.50–6.00	5.25–8.00	7.25–10.00	16.00–19.00

In the event that the hotel room rate structure is changed prior to the above convention these rates will be changed accordingly.

ALL RESERVATIONS MUST BE RECEIVED PRIOR TO December 31, 1947

Housing Bureau, American Association of Petroleum Geologists
910 Syndicate Trust Building,
St. Louis 1, Mo.

Please reserve the following accommodations for the American Association of Petroleum Geologists meeting in St. Louis on January 14–15, 1948

Single Room..... Double Bedded Room..... Twin Bedded Room.....
2 Room Suite..... Other Type of Room.....
Rate: From $.....to $..... First Choice Hotel.....
Second Choice Hotel.....
Third Choice Hotel.....
Arriving at Hotel (date).....hour.....A. M.....P. M. Leaving (date).....
hour.....A. M.....P. M.

THE NAME OF EACH HOTEL GUEST MUST BE LISTED. Therefore, please include the names of *both* persons for *each* double room or twin bedded room requested. Names and addresses of all persons for whom you are requesting reservations and who will occupy the rooms asked for:

.....
.....
.....
.....

(Individual Requesting Reservations)
Name.....
Address.....
City and State.....

If the hotels of your choice are unable to accept your reservation the Housing Bureau will make as good a reservation as possible elsewhere providing that all hotel rooms available have not already been taken.

will
I will not attend smoker

will
I will not attend dinner dance

TECHNICAL PROGRAM

REGIONAL PAPERS

1. "Tectonics of North-Central United States," Dorsey Hager
2. "Origin and History of the Eastern Interior Basin," J. M. Weller
3. "Correlations of the Chester Series in Illinois and Indiana," Elwood Atherton and David H. Swann
4. "Structural and Fault Patterns of the Eastern Interior Basin," Stuart K. Clark and J. S. Royds
5. "LaSalle Anticlinal Belt," A. H. Bell
6. "Bainbridge Lithologies of Southern Indiana and Illinois," E. J. Combs and Ralph Esarey
7. "Deep Drilling and Deeper Possibilities in Illinois," L. E. Workman and A. H. Bell
8. "History of Earthquakes in the Mississippi Valley," James B. MacElwane
9. "Geology of Recent Deep Tests in Kentucky and Tennessee," W. L. Effinger
10. "Recent Activities and Geology of Traverse Fields of Western Michigan," Rex Grant
11. "Niagaran and Albion Rocks in the Michigan Basin," George V. Cohee
12. "Subsurface Zones of the Plattin-Joachim of Eastern Missouri," J. G. Grohskopf

FIELD PAPERS

13. "Geology of Clay City, Noble, Dundas, and Boos Fields, Illinois," Darsie A. Green
14. "Geology of Wabash Valley Graben Fields, Illinois and Indiana," Victor R. Gallagher
15. "Geology of Benton Field, Illinois," J. V. Howell
16. "Geologic Aspects of Pressure Maintenance at Dix Field, Illinois," J. P. Smith
17. "Geology of Mattoon Field, Illinois," C. Doh
18. "Geology of St. Jacobs Field, Illinois," E. A. Obering and Julian W. Smith
19. "Geology of the Uniontown Consolidated Field, Kentucky," D. G. Sutton
20. "Geology of the Hitesville Consolidated Field, Kentucky," H. H. Bybee
21. "Geology of the Slaughters Field, Kentucky," Iley B. Browning
22. "Geology of the Coldwater Field, Michigan," R. H. Wolcott

GEOPHYSICAL AND ELECTRICAL-LOGGING PAPERS

23. "Electrical Well-Logging Symposium," Carl A. Bays
24. "Reflection Seismograph in Illinois," Homer C. Moore

PACIFIC SECTION ANNUAL MEETING, PASADENA NOVEMBER 6–7, 1947

The annual joint fall meeting of the Pacific Section of the American Association of Petroleum Geologists and the Society of Economic Paleontologists and Mineralogists, and the Pacific Coast District of the Society of Exploration Geophysicists was held at the Huntington Hotel, Pasadena, on November 6 and 7. The meeting was attended by geologists, paleontologists, geophysicists, and engineers to hear the presentation of papers on a wide variety of geological problems related to the ever increasing search for additional petroleum reserves.

On Thursday morning, November 6, the A.A.P.G. meeting opened with an all-day symposium on "Occurrence and Production of Oil from Fractured Rocks," a topic of interest to all coast geologists. At the Thursday noon luncheon, Ward C. Smith of the United States Geological Survey at San Francisco, spoke about "The Program of the United States Geological Survey." Three hundred five attended the luncheon.

The S.E.G. held a symposium on Thursday morning, "Correlation in California," and in the afternoon a series of papers of general interest was presented.

The S.E.P.M. held a dinner meeting on Thursday evening at the Pasadena Athletic Club. The program consisted of two interesting papers by Earl Meyers and Parker D. Trask.

On Friday, November 7, the A.A.P.G. program included a series of papers of general interest to Pacific Coast geologists. The afternoon session was high-lighted by the talk given by E. DeGolyer, distinguished lecturer, on "Prospecting for Petroleum."

The meetings terminated with a formal dinner-dance on Friday evening, attended by 423 persons. The total registration at the meeting was 503.

PACIFIC SECTION PAPERS AND ABSTRACTS

1. "Introductory Remarks of Symposium on Occurrence and Production of Oil from Fractured Rocks in California," ROLLIN ECKIS, Richfield Oil Corporation, Los Angeles.

2. "Summary of Production from Fractured Rock Reservoirs in California," W. S. EGGLESTON, Union Oil Company, Los Angeles.

The main source of oil production in California is in sand reservoirs. In recent years, however, production from fractured rock reservoirs has gained prominence. Fractured rock reservoirs can in general be divided into two groups: fractured cherts and shales in sedimentary beds and fractured metamorphosed basement rocks. Approximately 55,000 barrels of oil per day are being produced at present from fractured rock reservoirs. It is estimated that 15,000 barrels per day are being produced from fractured basement rocks and 40,000 barrels per day from fractured cherts and shales.

3. "Occurrence and Origin of Chert in the Monterey Formation," M. N. BRAMLETTE, University of California at Los Angeles.

Chert is less common than the other siliceous rocks in the Monterey but is locally prominent, especially in lower parts of the formation. Evidence is presented indicating that most of the siliceous rocks were formed through an alteration of originally diatomaceous rocks, the chert forming from beds and areas of relatively pure diatomaceous deposits. Most of this alteration by solution and recementation was after burial of the deposits.

Surface rocks commonly show recementation of the fractured cherts. More open fractures might persist, however, if accumulation of oil were nearly coincident with some of the structural deformation and fracturing.

4. "Fractured Reservoirs of the Santa Maria District," L. J. REGAN, JR., General Petroleum Corporation, Santa Maria, and A. W. HUGHES, Union Oil Company, Santa Maria.

Cumulative production of the Santa Maria district to January 1, 1947, was 250,637,000 barrels of which an estimated 77% originated in fractured rocks and 23% in oil sands. 74.5% of the oil was produced from fractured rocks in the Monterey formation and 2% from fractured "Knoxville" sandstone. Monterey fractured rocks in order of importance include (1) Mohnian cherts, (2) Luisian calcareous shale, and (3) Mohnian platy siliceous and porcellaneous shale. The distribution, age, and character of fractured zones are illustrated by stratigraphic sections. The distribution of maximum chert development suggests chert originated as a sedimentary facies. General characteristics of potentially productive fractured rocks of the district are analyzed and their permeabilities and porosities as indicated by production data are discussed.

5. "Oil Production from Fractured Rocks on West Side San Joaquin Valley," S. M. REYNOLDS, consulting geologist, Taft.

There are three known areas on the west side of the San Joaquin Valley where oil is produced exclusively from fractured rocks. These are in the South Belridge, Elk Hills, and Sunset oil fields. In each accumulation the structure is anticlinal; the fractured rocks are shale of upper Miocene age. The physical characteristics of the fractured rocks are not well known generally. The upper Miocene contains considerable brittle siliceous shales on the west side of the San Joaquin Valley which are known to have favorable reservoir characteristics in some places where tested. The distribution of these members is discussed.

6. "The Nature of the Basement Complex Oil Reservoir, Edison Oil Field, California," J. C. MAY and R. L. HEWITT, Tide Water Associated Oil Company, Bakersfield.

The completion of the H. H. Magee and Independent Exploration Company's "Brockman" well No. 3, Sec. 13, T. 30 S., R. 29 E., MDB & M, in the Edison field, Kern County, initiated commercial production from basement complex rocks in the San Joaquin Valley. At the present time about 1,500 acres of these rocks are oil productive in this field. The geologic structure of the field at basement complex depth is a faulted, dome-like fold with extensive south and west flanks, but with the north and east flanks shortened by faulting. The basement complex rocks are divisible into two groups: metamorphic rocks derived from sediments and igneous intrusives, and a younger igneous rock (Sierra Nevada) which was the chief cause of metamorphism in the older rocks. The metamorphic rocks in order of their probable age are (1) McCowan schist, (2) Hershey schist, (3) Dougherty schist, and (4) felsites. The McCowan schists are satiny, lead-gray, laminar rocks of sedimentary origin which occupy the eastern part of the field. The Hershey schists of doubtful sedimentary origin, are pistachio green, poorly laminated rocks. The Dougherty schists are variously metamorphosed fine-grained igneous rocks of probable malachite or diorite-aplite composition which comprise the west half of the basement producing area. The felsites are fresh, fine-grained igneous rocks, mineralogically akin to the Dougherty schists, which occur as segregations throughout the field. The quartz diorite of the Sierra Nevada batholith bounds the east edge of the oil field. Metamorphism is regional,

characteristic of the epizone, and its effects increase as the quartz diorite is approached. The oil originated in the westerly extending Tertiary sedimentary basin and migrated into the pore and fracture spaces of the structurally higher schist. Its accumulation apparently is unaffected by the type of schist, but is governed by the degree of metamorphism, fracturing, and the control of several large faults.

7. "Examples of Electrical Logs in Fractured Rocks," R. D. FORD, Schlumberger Well Surveying Corporation, Long Beach, and MILTON E. LOY, Bakersfield.

A discussion of electrical logs in fractured rocks is of interest in this symposium because, to the geologist and engineer, not only does a fractured rock reservoir require a different interpretive technique, so also does the electric log. Inasmuch as the electrical characteristics of basement rocks, fractured shales, and cherts may all be similar, all are referred to as fractured rocks.

Slides are shown illustrating the following areas:

Santa Maria cherts	Elk Hills chert and shales
Edison schist	Newport Beach—fractured shales
Maricopa shales	Wilmington schist

These illustrations show that there is apparently very little correlation between resistivity and production. This apparent lack of correlation may be attributed to the fact that the physical characteristics controlling resistivity are not necessarily the same as those which control production.

8. "Summary Remarks Concluding the Symposium on the Occurrence and Production of Oil from Fractured Rocks in California," ROLLIN ECKIS.

9. "Summary of Geology and Exploration in Sacramento Valley," W. E. MCKITRICK, Shell Oil Company, Sacramento.

Summarizes the stratigraphy and structure of the gas fields in the Sacramento Valley, with a summary of statistics on distribution and results of exploration. Slides show location of fields, selected type logs to illustrate stratigraphy and seven regional geologic sections.

10. "Summary of Geology and Exploration in Salinas Valley," J. E. KILKENNY, Chanslor-Canfield Midway Oil Company, Los Angeles.

Intermittent unsuccessful exploration for oil has been carried on in the Salinas Valley for 50 years. A favorable sedimentary section of both source and reservoir beds has prompted a periodic renewal of wildcat drilling, the most recent of which was undertaken in 1946 and is still in progress. The general stratigraphy and structure of the basin are reviewed and some exploration statistics presented. Recent wells drilled have shown that the Vaqueros sand is less extensive than originally thought. In addition, new light has been thrown on the King City fault, revealing two periods and types of movement and indicating that B. L. Clark's fault-block theory of the origin of present-day structural features may be valid in this particular area.

11. "Oil and Gas Prospects of Washington and Oregon," HAMPTON SMITH, consulting geologist, Los Angeles.

After many years of nearly complete quiescence, scientific prospecting for oil and gas in Washington and Oregon entered a period of accelerated activity during the war, which activity will probably continue for several years.

The area of interest included several non-contiguous districts in a region 400 miles long and 100 miles wide, covering most of western Washington and Oregon. Operators have carried out extensive projects of surface mapping and seismograph work in one or more of these districts and more than 15 wildcat wells were drilled or are drilling. No commercial production has been developed but some encouraging showings of oil and gas have been reported and much of new geological information has been obtained.

A brief outline of the geology of western Washington and Oregon is presented and an attempt is made to evaluate the prospects of this territory in light of the data obtained in the current exploration cycle.

12. "Relative Cost of Finding Oil in California," GRAHAM B. MOODY, Standard Oil Company, San Francisco.

Statistics indicate that the cost of finding oil in California is not by any means a fixed quantity but fluctuates between wide limits. The variables that affect finding costs are discussed.

13. "Prospecting for Petroleum," E. DEGOLYER, A.A.P.G. distinguished lecturer, Dallas, Texas.

A critical examination of the theories of oil occurrences from the time of announcement of the anticlinal theory to the present. The outlook for prospecting in the United States is discussed and the effectiveness of current exploration procedures considered on a quantitative basis.

14. "Ecological Relationships of Recent Foraminifera," EARL MEYERS, University of California at Berkeley.

The author is a marine biologist, formerly with the Scripps Institution of Oceanography and the Johns Hopkins Marine Station. He discusses the paleogeographic factors of foraminiferal ecology, including depth, distance from shore and sedimentary conditions, and attempts to apply these factors in the ecology of living foraminifera to environmental significance of fossil foraminifera.

15. "Determination of Potential Oil Source Rocks," PARKER D. TRASK, Division of Mines, California State Department of Natural Resources, San Francisco.

The author, temporarily on leave from with the United States Geological Survey, and leader of research in the subject, summarizes what is known about recognition of strata as potential oil source rocks.

PACIFIC SECTION COMMITTEES AND CHAIRMAN

EXECUTIVE COMMITTEE

MARTIN VAN COUVERING, President — W. P. WINHAM, Vice-President
E. R. ATWILL, Past-president — CLIFTON W. JOHNSON, Secretary-treas.
JOHN E. KILKENNY, Member

Program: JAMES C. KIMBLE, Chairman
Arrangements: HARVEY LEE, Chairman
Publicity: MILTON LEWIS, Chairman
Finance: J. R. PEMBERTON, Chairman

Officers of the Pacific Section, elected at this meeting are: president, W. P. WINHAM, Standard Oil Company of California; vice-president, HARVEY W. LEE, Union Oil Company of California; secretary-treasurer, P. H. GARDETT, General Petroleum Corporation.

SOUTH TEXAS REGIONAL MEETING, SAN ANTONIO NOVEMBER 5–6, 1947

San Antonio was the city of the South Texas regional meeting of the Association on November 5 and 6 and the South Texas Section was host. The Section was also observing its 14th annual meeting and field trip, following the hiatus of the war years. The Plaza Hotel, on the bank of the winding San Antonio River, served well for the needs and the enjoyment of the meeting. Its long lobby, generously furnished with comfortable lounging places for conversational intervals in the full-packed program, led past the registration and ticket tables to the mezzanine ballroom where the technical program was presented. A small group of technical-scientific exhibits occupied the space at the ballroom entrance.

The San Antonio committees made full use of the two days of technical program and the two following days of field trips in arranging a continuous sequence of events for the 696 geologists, wives, and friends who registered. Special A.A.P.G. noon luncheons on the Plaza Roof on Wednesday and Thursday prevented over-crowding in the hotel coffee shop and dining room.

Following each day's presentation of papers nearly all of the members, it seemed, accepted the invitations to go by bus to the plant of the Edgar Tobin Aerial Surveys and the laboratories of the Petty Geophysical Engineering Company to inspect their methods and equipment and to enjoy their substantial and refreshing hospitality.

The ladies were delightfully entertained on Wednesday at the home of Mr. and Mrs. Wm. H. Spice, Jr. About 200 ladies attended this tea. On Thursday the ladies went on a sight-seeing trip, to visit the Alamo, missions, parks, and residential San Antonio.

A dinner and dance on the Plaza Roof, Thursday night, concluded the first two days of the meeting. On Friday an all-day field trip, by bus, was conducted as far south as Live Oak and Bee counties to visit Tertiary outcrops and to inspect oil fields in Atascosa and Karnes counties. On Saturday a forenoon trip was made to the laboratories of the Southwest Research Institute near San Antonio.

FIG. 1.—Group in Mezzanine Ballroom, Plaza Hotel, November 5, when L. F. McCollum spoke on "The United States Oil Man in a World Industry," at South Texas regional meeting.

OFFICERS OF SOUTH TEXAS SECTION

President, GUY E. GREEN — Vice-president, VAN A. PETTY, JR.
Secy.-treas., J. BOYD BEST — Past-president, THORNTON DAVIS
Member of executive committee, ROBERT S. MANN

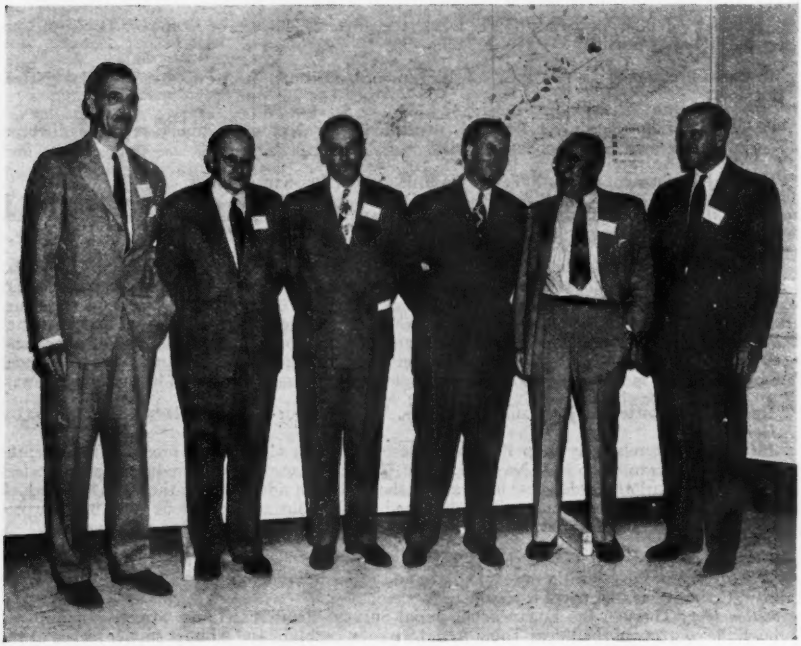

FIG. 2.—Chairmen and speakers, South Texas regional meeting. Left to right: W. H. Spice, Jr., Robert N. Kolm, Guy E. Green, L. F. McCollum, Thornton Davis, Bruce Scrafford.

CHAIRMEN OF ARRANGEMENTS

General chairman	ROBERT N. KOLM
Vice-general chairman	THORNTON DAVIS
Technical Program	WILLIAM H. SPICE, JR.
Hotels and Housing	THORNTON DAVIS
Finance	VAN A. PETTY, JR.
Vice-chairman	W. W. HAMMOND
Entertainment	M. A. ELMS
Ladies Entertainment	MRS. WM. H. SPICE, JR.
Field Trips	JAMES K. ROGERS
Vice-chairman	LEAVITT CORNING, JR.
Publicity	BRUCE SCRAFFORD
Exhibits	R. S. MANN
Reception and Registration	EDGAR W. OWEN
Transportation	HARVEY WHITAKER

PROGRAM AND ABSTRACTS

WEDNESDAY, NOVEMBER 5

1. "Welcome to South Texas," G. E. GREEN, president, South Texas Section, A.A.P.G., San Antonio

2. "Response," C. E. DOBBIN, president, American Association of Petroleum Geologists, Denver, Colo.

3. "Mineral Production in Texas," J. T. LONSDALE, director, Bureau of Economic Geology, University of Texas, Austin

4. "Research Program of the A.A.P.G.," S. W. LOWMAN, chairman, A. A.P.G. Research Committee, Houston

5. "Objectives of the Southwest Research Institute," RAY NEUMANN, public relations director, Southwest Research Institute, San Antonio

6. "Recent Development in South Texas," WM. H. SPICE, JR., San Antonio

Luncheon talk: "Why Didn't I Think of That?" EARL B. NOBLE, past-president, A.A.P.G., Los Angeles

7. "Jurassic Geology of Northern and Northwestern Gulf Coast," HENRY J. MORGAN, JR., Dallas
The area covered includes those parts of Louisiana, Arkansas, Texas, and northeast Mexico that are underlain, or thought to be underlain by Jurassic sediments. The purpose is to discuss the structural and stratigraphic development of the Jurassic in as much detail as the amount and character of the available information permits. Discussion and presentation of cross sections and isopach and facies maps of the various Jurassic units in the better explored regions of Arkansas, Louisiana, and Texas. Comparison is made with possible developments of Jurassic sediments in southwest Texas.

8. "Imogene, Charlotte, and Jourdanton Oil Fields, Atascosa County, Texas," HENRY D. MCCALLUM Corpus Christi
In these fields, relatively deep Edwards limestone (Lower Cretaceous) produces from depths ranging from 6,800 to 7,600 feet. Navarro sands (Upper Cretaceous) also produce near 5,000 feet in depth in the Charlotte field. These fields are on the upthrown sides of up-to-the-coast faults which parallel and *en echelon*. The geology will be discussed from the surface formations down into the producing Edwards section. The development and a few statistics on each field are also given.

9. "Gas Reserves of South Texas," FRED P. SHAYES, Beeville
A discussion of the gas withdrawals to date and the gas reserves in the area covered by the taxes Railroad Commission's Districts 1, 2, and 4.
Inspection tour: Through the Edgar Tobin Aerial Surveys Plant, 114 Camp Street, San Antonio. Through the courtesy of the Edgar Tobin Aerial Surveys, cocktails and a buffet supper served at the Plant.

Evening address: "The United States Oil Man in a World Industry," L. F. MCCOLLUM, New York City

THURSDAY, NOVEMBER 6

10. "Shallow Wilcox Fields in South Texas," O. G. MCCLAIN, Corpus Christi
The Wilcox (Eocene) fields from Fayette County to the Rio Grande River are discussed from the 5,000-foot contour on top of the Wilcox formation upward. Structural contour maps and cross sections of the fields are presented. Producing conditions are related in detail.

11. Slick-Wilcox Field, DeWitt and Goliad Counties, Texas," LOUIE SEBRING, JR., San Antonio
The history, stratigraphy, structure, development, and possible future development of the field are covered. Structure maps on several horizons are presented, together with cross sections, type log, and a location map. A discussion of the structure of the field is emphasized.

12. "Seeligson Field, Jim Wells County, Texas," BRUCE SCRAFFORD, San Antonio
The Seeligson field discovery in December, 1937, by the Magnolia Petroleum Company's A.A. Seeligson No. 7 led to the development of what is now the largest oil and gas production area of the Texas Gulf Coast and is declared by some to be the second largest in the United States. During the 10 years following the discovery, 478 wells have been drilled in the Seeligson field proper—185 of the 478 productive tests were dually completed, the result being 663 effective wells producing from 39 separate reservoirs.
The development of the Blucher, Canales, and Tijerina fields on the south, having producing reservoirs common with the east flank production of Seeligson, indicates the likelihood of a continu-

ous productive area from Seeligson to the La Gloria area on the southwest. These discoveries and extensions south and west and the discoveries of the Borregas and Monte Negra fields on the northeast appear to make inevitable the merging of a producing area in excess of 55 miles in length and 3–7 miles in width, extending through parts of four South Texas counties.

13. "Importance of Water in the Production of Oil," DALE H. ROWDEN, San Antonio
A general discussion on the different types and physical characteristics of the waters present in most reservoirs, and their function in the production of oil when properly controlled and when abused.

14. "Water Permeability," KARL H. SCHMIDT, San Antonio
Permeability measurements using salt water as the flow fluid show the presence of hydratable clay minerals in many gas- and oil-productive sands. The presence of interstitial water in reservoirs leads to the supposition that true reservoir permeability is more nearly approached by water flow than by normal air flow determinations. A discussion of laboratory-water and air-flow measurement and comparative data are presented.

15. "A Look Backward and a Look Forward in Geophysics in South Texas," PAUL WEAVER, Houston

Inspection tour: through the Petty Geophysical Engineering Company laboratories, 317 6th Street San Antonio.

Dinner and dance: Plaza Hotel Roof

FRIDAY, NOVEMBER 7

Field trip: by bus, returning to San Antonio the same evening. Outcrops in the Tertiary, from the Midway group (lower Eocene) to the Lissie formation (Pleistocene), extending as far south as Live Oak and Bee counties. New oil fields in Atascosa County, producing from Navarro sand and Edwards limestone formations and the Falls City field, Karnes County, producing from the upper Wilcox formation.

SATURDAY, NOVEMBER 8

Field trip: by bus, returning by noon. Inspecting headquarters and laboratories of the recently established Southwest Research Institute, eight miles west of San Antonio.

LADIES ENTERTAINMENT

WEDNESDAY, NOVEMBER 5

Tea: for visiting ladies, at the residence of Mrs. Wm. H. Spice, Jr., 632 Elizabeth Road, Terrell Hills

THURSDAY, NOVEMBER 6

Sight-seeing trip: by bus to visit the Alamo, Missions, parks, and residential districts

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ALBERTA SYMPOSIUM

The Alberta Society of Petroleum Geologists has undertaken the preparation of a symposium on the geology and oil fields of Alberta and contiguous parts of the Alberta Basin. The symposium committee consists of L. M. CLARK, chairman, J. O. G. SANDERSON, J. B. WEBB, and J. D. WEIR. During the past year, the papers here listed were presented before the Society and these are now in various stages of preparation for publication.

"Devonian Stratigraphy of the Alberta Plains and Rocky Mountain Front Ranges," by IAN M. COOK.
"Mississippian and Later Paleozoic Stratigraphy of the Rocky Mountain Front Ranges," by H. H. BEACH.
"Pre-Waterways Paleozoic Stratigraphy of the Alberta Plains," by J. R. MCGEHEE.
"Mississippian Stratigraphy of the Alberta Plains," by D. G. PENNER.
"Jurassic Sections in the Foothills of Alberta and Northeastern British Columbia," by J. SPIVAK.
"Lower Cretaceous of the Alberta Plains," by D. B. LAYER.
"Jurassic Sections of Southern Alberta," by J. D. WEIR.
"Marine Upper Cretaceous of the Alberta Foothills." by J. C. SCOTT.
"Pakowki Formation of Southern Alberta," by J. D. WEIR.
"Milk River Formation of Alberta," by J. D. WEIR.
"Lea Park and Belly River Formations of East Central Alberta," by E. W. SHAW and STAN HARDING.
"Bearpaw and Later Formations of the Alberta Plains," by F. G. LINES.

"Geology of the Rocky Mountain Front Ranges in the Vicinity of Bow River, Alberta," by L. M. CLARK.
"Turner Valley Oil Field," by W. B. GALLUP.
"Vermilion Oil Field," by NORMAN SOUL.
"Lloydminster Oil Field," by J. S. IRWIN.
"Summary of the Geological History of the Alberta Basin," by A. J. GOODMAN.

Papers which are yet to be presented before the Society are the following.

"Paleontological Zones of the Devonian," by P. S. WARREN.
"Triassic Stratigraphy of Alberta and Northeastern British Columbia," by C. O. HAGE.
"Lower Cretaceous of the Foothills of Alberta and Northeastern British Columbia," by J. B. WEBB.
"Upper Cretaceous of the Peace River Area," by JOE GLEDDIE.
"Colorado Stratigraphy of the Alberta Plains," by W. P. HANCOCK.
"Pale and Foremost Beds of Southern Alberta," by M. B. B. CROCKFORD.
"Conrad and Taber Oil Fields," by A. R. KEEVIL.
"Princess Oil Field," by J. G. GRAY
"Viking-Kinsella Gas Field," by S. E. SLIPPER.
"General Structure Map of the Alberta Plains," by JIM HUMPHRIES.
"Non-Marine Upper Cretaceous and Early Tertiary of the Alberta Foothills," by H. KUNST.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 31, NO. 12 (DECEMBER, 1947), PP. 2247-2250

AT HOME AND ABROAD

CURRENT NEWS AND PERSONAL ITEMS OF THE PROFESSION

R. O. YOUNG has left the Trinidad Leaseholds, Ltd., at Pointe á Pierre, Trinidad, B. W. I., to go to the North Venezeulan Petroleum Company. Ltd., at Caracas, Venezuela.

L. B. CULLIGAN, of the Colorado School of Mines, is employed by The California Company at Brookhaven, Mississippi.

ROBERT F. DEWEY, of the University of Oklahoma, is employed by the Vicker Petroleum Corporation, at Oklahoma City, Oklahoma.

GLEN C. WOOLLEY, of the Transwestern Royalty Company, San Antonio, Texas, died on October 1 at the age of 44 years.

The Province of Nova Scotia and the Massachusetts Institute of Technology have agreed to establish an Institute of Geology with headquarters at Crystal Farm on St. George's Bay on Antigonish harbor, Nova Scotia. This cooperative venture was initiated by W. L. WHITEHEAD of M. I. T., D. J. MACNEIL of St. Francis Xavier University at Antigonish, and the Nova Scotia Research Foundation, and it is sponsored by the Nova Scotia Department of Mines.

R. J. KNOX has accepted a position as field geologist with Schweer and Hardison, consulting geologists of Wichita Falls, Texas, and will be located in the San Juan Basin area of New Mexico and Colorado.

L. W. LEROY, chief micropaleontologist and stratigrapher for the Richmond Exploration Company, Venezuela, has resigned to become associate professor in the department of geology, Colorado School of Mines, Golden, Colorado.

HENRY F. SCHWEER, consulting geologist of Wichita Falls, Texas, died in a plane crash near Flectra, October 25, at the age of 43 years.

C. O. WILLSON, editor of the *Oil and Gas Journal*, spoke on "Seeking Oil in Arctic Alaska," before the joint meeting of the Tulsa Geological Society and the Mid-Continent Section of the American Institute of Mining and Metallurgical Engineers at the Mayo Hotel, Tulsa, Oklahoma, November 3.

W. EARLE SHAMBLIN is district geologist for the Deep Rock Oil Corporation, in charge of land and exploration in the Shreveport area, Louisiana.

WILLARD O. PYE, formerly with The Texas Company at Casper, Wyoming, is in the geological department of the North Dakota Agricultural College, Fargo, North Dakota.

ROY HARRIS has resigned from the Atlantic Refining Company and has accepted the position of district geologist with the Lion Oil Company at El Dorado, Arkansas.

FRANK G. EVANS, formerly with the Shell Oil Company, Inc., is now associated with CARLETON D. SPEED, JR. Second National Bank Building, Houston 2, Texas, in the development of oil properties.

The committee on Russian literature of the Geological Society of America has begun the compilation of a list of translations from Russian into English of geologic papers and

books, that is, a list of translations extant in manuscript form in the United States. The word *geologic* is used here in its widest sense to extend inclusively from geophysics to paleontology. RONALD K. DEFORD, chairman of the committee, requests that information about such translations be sent to him, Box 1814, Midland, Texas, or to the Geological Society of America, 419 West 117th Street, New York City. If information about translations of recent publications is received soon enough, it will be included in forthcoming volumes of the *Bibliography and Index of Geology Exclusive of North America* and the *Bibliography of Economic Geology*, subject to permission from proprietors of translations.

J. T. PADDLEFORD, formerly geologist with the Stanolind Oil and Gas Company at Wichita, is chief geologist and petroleum engineer for the R. Olsen Company at Oklahoma City.

CLARK R. STEINBERGER resigned from the position of district geologist for the Skelly Oil Company at Midland, Texas, November 1, to become manager of the new office of the United States Smelting, Refining, and Mining Company at Midland, which is to be the company's headquarters in oil activities.

OLAF F. SUNDT has been transferred from the American Embassy at Lima, Peru, to the American Embassy at Paris, France, in the same capacity as petroleum attaché. He will spend 2 months in the United States this winter on consultation at the Department of State and on leave before sailing for France in February.

CHARLES S. PERCY, formerly with the Harrison Oil Company at Houston, is in the geological department of the Stanolind Oil and Gas Company at San Antonio, Texas.

LAURENCE F. DAKE has resigned from the Houston Oil Company of Texas at San Antonio to accept a position as geologist with the Arabian American Oil Company with headquarters at Dhahran, Saudi Arabia.

GORDON RITTENHOUSE resigned from the United States Geological Survey, effective the first of October, and will do part-time consulting outside of the Appalachian basin in addition to continuing teaching at the University of Cincinnati.

PHIL K. COCHRAN, formerly assistant division superintendent for the Carter Oil Company, is now associated with The Palmer Oil Corporation and has opened an office in Shreveport, Louisiana.

JOHN G. BARTRAM, with the Stanolind Oil and Gas Company, Tulsa, Oklahoma, gave a talk on "Geology and Oil Possibilities of Jurassic of Colorado" before the Shawnee Geological Society, October 16.

LAURENCE BRUNDALL, vice-president of Geophoto Services, Denver, addressed the first fall meeting of the Wyoming Geological Association at Casper, Wyoming, on October 17. The title of his paper was "Photogeology and Its Applications to Oil Exploration."

F. JULIUS FOHS, consulting geologist of Houston, Texas, gave a series of lectures at the geological department of Columbia University, New York City, on "Oil-Finding Practice and Theory," during October. On December 10 he addressed the Eastern Section of the A.A.P.G., in New York, on the "Oil-Reserve Provinces of Russia."

New officers of the Wyoming Geological Association at Casper are: president, HENRY C. REA, consultant; first vice-president, M. P. TIXIER, Schlumberger Well Surveying Corporation; second vice-president, W. S. KNOUSE, Tide Water Associated Oil Company; secretary-treaturer, H. E. SUMMERFORD, Chemical Laboratories, Inc.

FELIX A. VOGEL, JR., recently with the United States Bureau of Mines at Dallas, is consulting geologist for Ralph E. Davis, Inc., Commerce Building, Houston, Texas.

ELEANOR T. CALDWELL has left the Shell Oil Company, Inc., to go with the Humble Oil and Refining Company, Tallahassee, Florida.

KENNETH C. ANDERSON, formerly with the Standard Oil Company of Texas, is now in the employ of the Skelly Oil Company, Midland, Texas.

FREDERICK H. KATE has resigned his position with the Shell Oil Corporation to become associated with RALPH FILLMORE in the Apco Tower, Oklahoma City, Oklahoma.

A. H. GARNER may be addressed in care of Conselho Nacional do Petroleo, Av. Presidente Wilson No. 164–9° Rio de Janeiro, Brasil.

DON L. CARROLL has left the United States Geological Survey to become assistant to director MAX BALL of the Oil and Gas Division of the Department of the Interior, Washington, D. C.

R. A. RANK, formerly with the British-American Oil Producing Company at Shreveport, Louisiana, is in independent work at Graham, Texas.

F. STEARNS MACNEIL, United States Geological Survey, has returned from Okinawa and is now stationed at Plant City, Florida, where he is engaged in a study of the stratigraphic relationships of the Bone Valley phosphate deposits. His address is Box 1390, Plant City.

H. R. TAINSH is with the Burmah Oil Company (Burma Concessions) Ltd., Yenangyaung (Magwe District), Upper Burma.

IONEL I. GARDESCU, recently with The Texas Company, Houston, Texas, is petroleum engineer and geologist with Ralph E. Davis, Inc.

DAVID M. GRUBBS, formerly with the Danciger Oil and Refining Company, Fort Worth, Texas, is with the Drilling and Exploration Company, Inc., Dallas.

THOMAS W. BLACKSTONE has left the Gulf Oil Comporation and is now employed by the Cities Service Oil Company, Houston, Texas.

DEWITT C. VAN SICLEN is employed by the Drilling and Exploration Company, Inc., Dallas, Texas.

FRANK C. KALLINA has resigned from the Standard Oil Company of Texas to become chief geologist for the CAM Corporation, Corpus Christi, Texas.

RALPH E. SMITH is doing field work in the Fuels Section of the United States Geological Survey. His present address is Box 382, Sparta, Tennessee.

EUGENE E. BROSSARD, of Madison, Wisconsin, is in the employ of the Aereocias Occidentales, San José, Costa Rica, C. A.

C. HEWITT DIX is resigning his position with the United Geophysical Company to become associate professor of geophysics at the California Institute of Technology, Pasadena, beginning January 1.

The geological library of the late KENDALL E. BORN is for sale at 609 East 12th Street, Rolla, Missouri.

J. HARLAN JOHNSON spoke before the Rocky Mountain Association of Geologists at Denver, Colorado, November 17, on "The Reefs at Bikini."

The Dallas (Texas) Geophysical Society was organized on October 1. Officers are: president, A. E. MCKAY, Atlantic Refining Company; first vice-president, W. W. NEWTON, Geotechnical Corporation; second vice-president, C. J. DONNALLY, Western Geophysical Company; secretary-treasurer, D. RAY DOBYNS, Magnolia Petroleum Company. Meetings are to be held monthly.

GEORGE DICKINSON, subsurface geologist, for many years with the Caribbean Petroleum Company in Venezuela, is now attached to the regional production department of the Shell Oil Company, Inc., Houston, Texas.

The National Research Council announces for the academic year 1948–49 postdoctoral fellowships designed to permit young men and women who have demonstrated their ability in research in the natural sciences to spend additional time in uninterrupted study. Candidates must have completed the requirements for the doctor's degree before entering upon their fellowships. Fields of study embraced by the program include the physical and mathematical sciences, geology and geography, biological and agricultural sciences, anthropology and psychology. Stipends are at the rate of $2,500 per annum, plus travel to the place of study. Further particulars concerning these programs may be obtained from the National Research Council Fellowship Office, National Research Council, 2101 Constitution Avenue, N. W., Washington 25, D. C.

The next meeting of the Pacific Coast Section of the Paleontological Society will be held in April, 1948, at the California Institute of Technology, Pasadena, California, in conjunction with the meeting of the Cordilleran Section of the Geological Society of America. A symposium will be held on the general subject, "Miocene-Pliocene boundary on the Pacific Coast, from the Viewpoint of the Vertebrate, Microfossil, and Megafossil Workers, together with the Field Relationships." Seven papers have already been offered. Contributions by interested workers are desired. The remainder of the meeting will be devoted to other subjects. Anyone interested, please contact HERDIS BENTSON (secretary), 225 Bush Street, San Francisco, Claifornia, or J. WYATT DURHAM (chairman), Department of Paleontology, University of California, Berkeley 4, California.

A field conference in central Colorado, sponsored by the Rocky Mountain Association of Geologists, was held in the summer of 1947. The guidebook for the conference includes a detailed road log from Denver to Glenwood Springs over U. S. Highways 40 and 6; Glenwood Springs to Leadville over Independence Pass; and Leadville to Cripple Creek, through Florissant. In addition to the road log the guidebook contains 10 papers on the geology of the central Colorado region, illustrated by maps and geologic cross sections. A selected bibliography lists about 80 papers on the region. A limited number of copies are available at $5.00 per copy. Address Rocky Mountain Association of Geologists, 230 New Customhouse, Denver 2, Colorado, N. W. Bass, Secretary-Treasurer. A part of the trip described in the guidebook will be repeated during the 1948 annual meeting of the A.A.P.G. at Denver next April.

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PUBLISHED
MONTHLY

Composed and Printed by
George Banta Publishing Company
Menasha, Wisconsin, U.S.A.

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ERRATA

FRONT COVER, JULY. 5th article of Contents: "Paleography" should be "Paleogeography."
PAGE 1620. Figure 1-a legend, last line: After "Beaumont," add "; QR, Recent." After "Thornthwaite," add "with(?). Formation contacts by broken lines."
PAGE 1626. Last line: "Four" should be "Seven."
PAGE 1630. Second line: After "northward," insert (—at times west and southwest—"
PAGE 1636. Fourth line: Change "recent time" to "the past decade."
PAGE 1648. Third line: "Fig. 2, b, a" should be "Fig. 2, b, c."
PAGE 1659. Lines 8 and 7 from bottom: Delete "In equal units, the equation is" and delete the equation.
PAGE 1661. Paragraph 27, line 2: After "currents," insert "in channels."
PAGE 1675. Author of Salt Creek article is John H. Beach, not J. C. Beach.
FRONT COVER, OCTOBER. Last article of Geological Notes: "Prospective" should be "Perspective."

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Treasurer - - - - - - - - R. W. Edmund
Globe Oil and Refining Company

Meetings: Technical program each month, subject to call by Program Committee, Oklahoma City University, 24th Street and Blackwelder. Luncheons: Every second and fourth Thursday of each month, at 12:00 noon. Y.W.C.A.

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Editor - - - - - - - - - Robert F. Walters
Box 661, Gulf Oil Corporation

Meetings: First and third Mondays, each month, from October to May, inclusive, at 8:00 P.M., University of Tulsa, Kendall Hall Auditorium. Luncheons: Every Friday (October-May), Chamber of Commerce Building.

PENNSYLVANIA

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Secretary - - - - - - - - - David K. Kirk
Gulf Research and Development Co., Box 2038
Treasurer - - - - - - - - - C. H. Feldmiller
111 Haldane Avenue, Pittsburgh 5

Meetings held each month, except during the summer. All meetings and other activities by special announcement.

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Vice-President - - - - - - Paul A. Grant
Gulf Oil Corporation, Box 110
Secretary-Treasurer - - - - - Robert J. Gutru
Cities Service Oil Company, Box 350

Meetings: Luncheon 1st and 3d Wednesdays of each month, 12:00 noon, Herring Hotel. Special night meetings by announcement.

TEXAS

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CORPUS CHRISTI, TEXAS

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Vice-President - - - - Robert D. Hendrickson
Union Oil Company of California
Secretary-Treasurer - - - - - - H. C. Cooke
c/o O. G. McClain, 224 Wilson Building

Regular luncheons, every Thursday, Terrace Annex Room, Robert Driscoll Hotel, 12:00. Special night meetings by announcement.

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Meyer and Achtschin
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Seaboard Oil Company
1400 Continental Building
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Geotechnical Corporation, Box 7166

Meetings: Monthly luncheons by announcement. Special night meetings by announcement.

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Phillips Petroleum Company
Box 208
Secretary-Treasurer - - - - Walter E. Long
Geir-Jackson Company, Inc.

Luncheons: Each week, Monday noon, Blackstone Hotel.
Evening meetings and programs will be announced. Visiting geologists and friends are welcome.

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Vice-President - - - - - - R. H. Schweers
The Texas Company, Box 1720
Secretary-Treasurer - - - - - R. W. Dudley
Pure Oil Company
Box 2107

Meetings: Luncheon at noon, Hotel Texas, first and third Mondays of each month. Visiting geologists and friends are invited and welcome at all meetings.

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J. M. Huber Corporation
721 Bankers Mortgage Bldg.
Vice-President - - - - - - A. F. Childers
Gulf Oil Corporation, Box 2100
Secretary - - - - - - - - Hershal C. Ferguson
Consultant, 1208 Esperson Building
Treasurer - - - - - - - - Eugene L. Earl
The British-American Oil Producing Company

Regular meeting held the second and fourth Mondays at noon (12 o'clock), Mezzanine floor, Rice Hotel. For any particulars pertaining to the meetings write or call the secretary.

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Vice-President - - - - - - Leonard T. Teir
Continental Oil Company, Hamilton Bldg.
Secretary-Treasurer - - - Joseph W. McDonald
Shell Oil Company, Inc., Box 2010, Radio Bldg.

Meetings: Luncheon 1st and 3rd Wednesdays of each month, 12:00 noon, Y.W.C.A. Evening meetings by special announcement. Visiting geologists and friends are cordially invited to all meetings.

TEXAS

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Santa Clara Oil Company
1016 South Texas Building

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Petty Geophysical Company

Secretary-Treasurer - - - - - - J. Boyd Best
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1417 Milam Building

Meetings: One regular meeting each month in San Antonio. Luncheon every Monday noon at Milam Cafeteria, San Antonio.

WEST TEXAS GEOLOGICAL SOCIETY

MIDLAND, TEXAS

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Republic Natural Gas Company
1505 Federal Street, Dallas 1, Texas

Vice-President - - - - - W. A. Waldschmidt
Argo Oil Corporation, Box 1814

Secretary-Treasurer - - - Charles F. Henderson
Stanolind Oil and Gas Company, Box 1540

Meetings will be announced.

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Secretary-Treasurer - - - - Alan H. McClain
Owens, Libbey-Owens Gas Department, Box 4158

Editor - - - - - - - - - R. Douglas Rogers
South Penn Natural Gas Company
Union Trust Building, Parkersburg, West Virginia

Meetings: Second Monday, each month, except June, July, and August, at 6:30 P.M., Daniel Boone Hotel.

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CASPER, WYOMING
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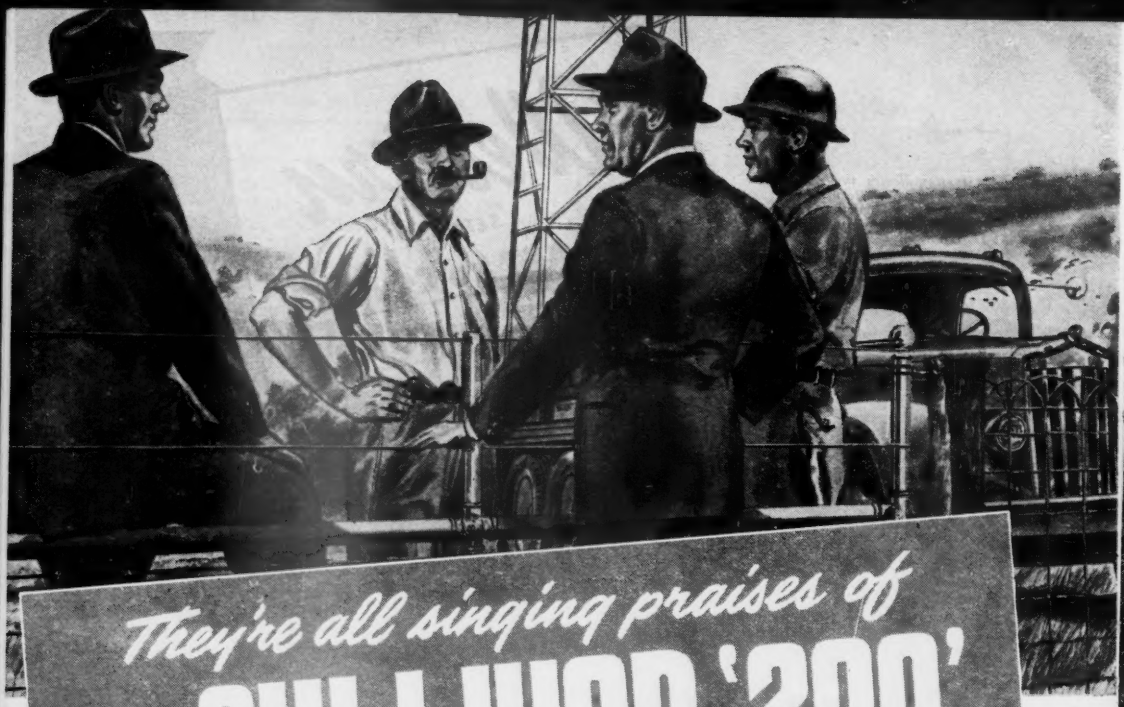

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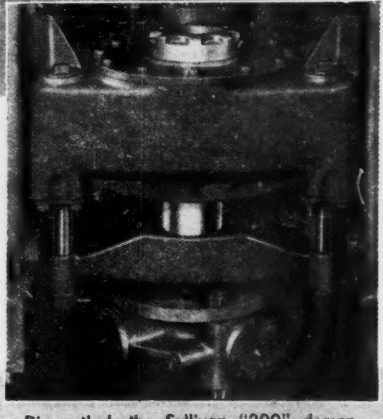

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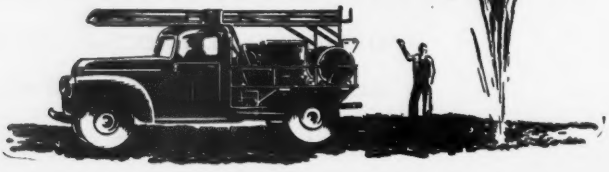

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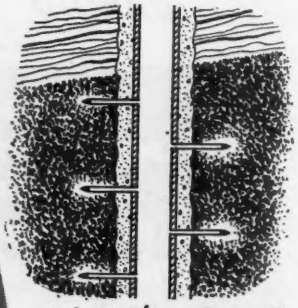

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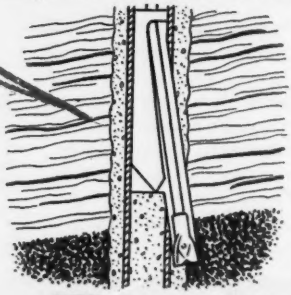

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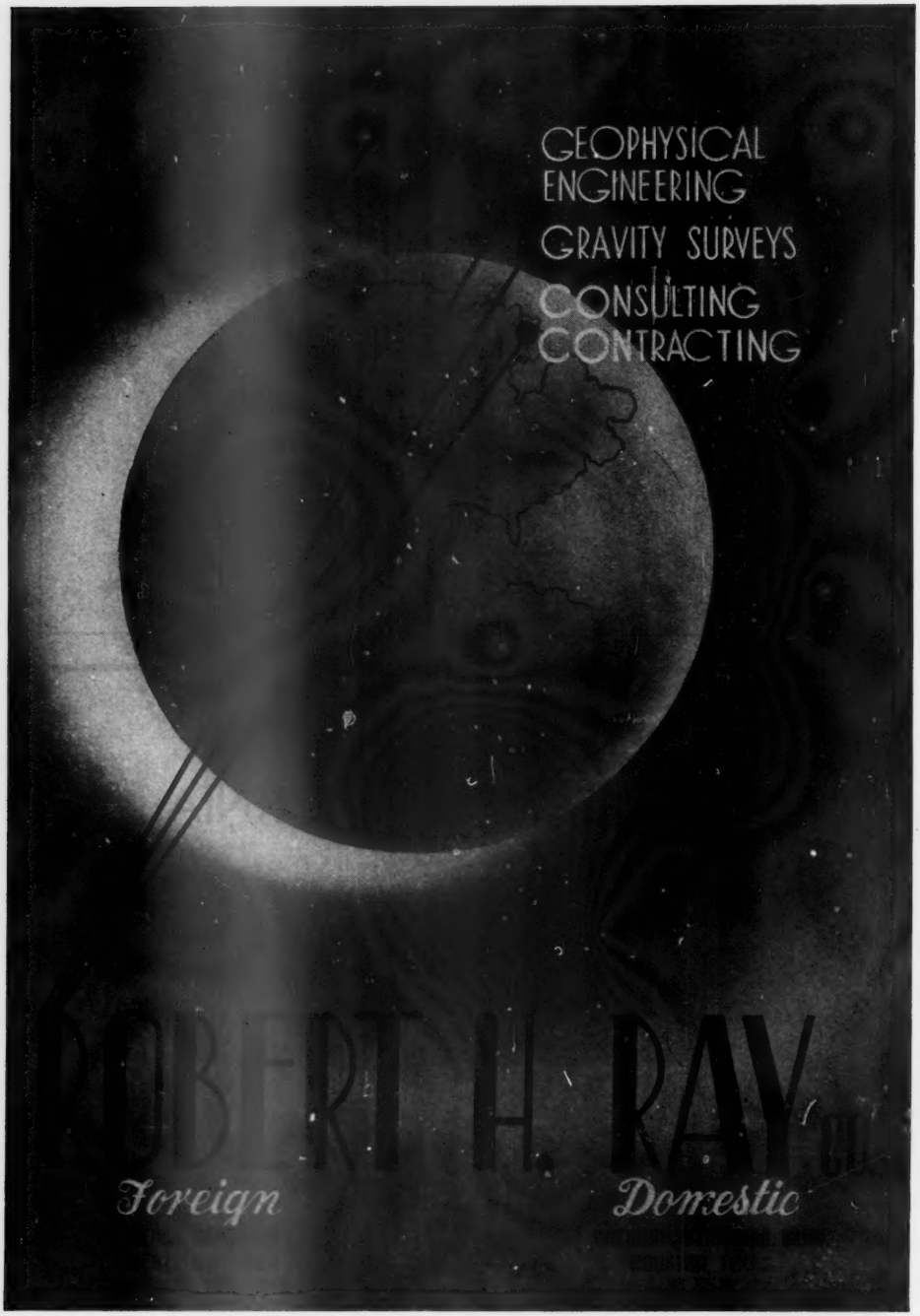
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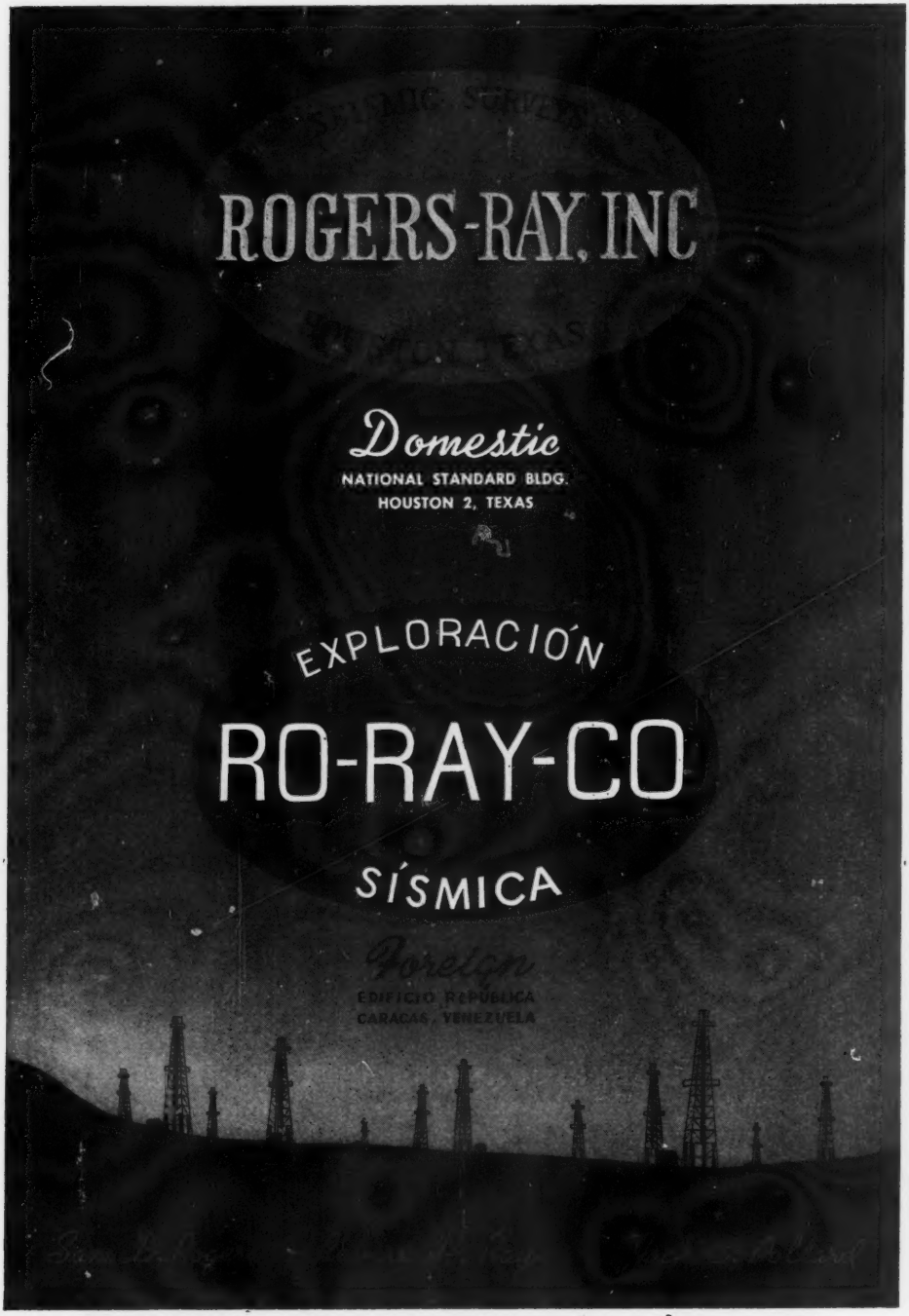
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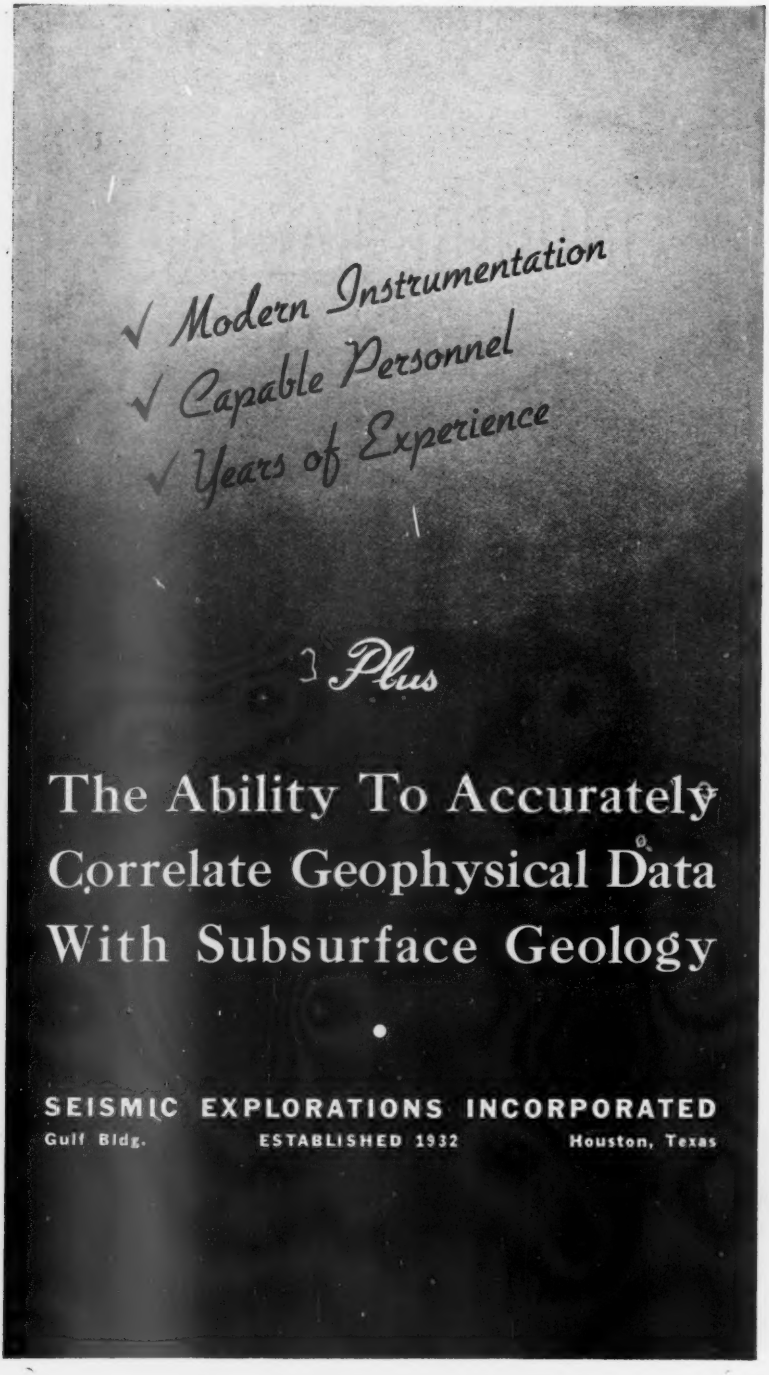
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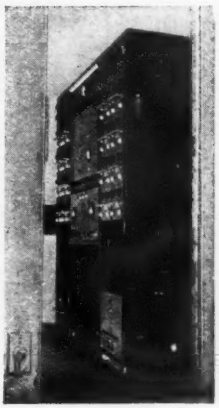

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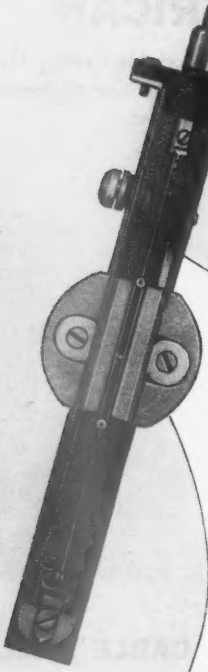

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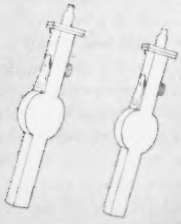

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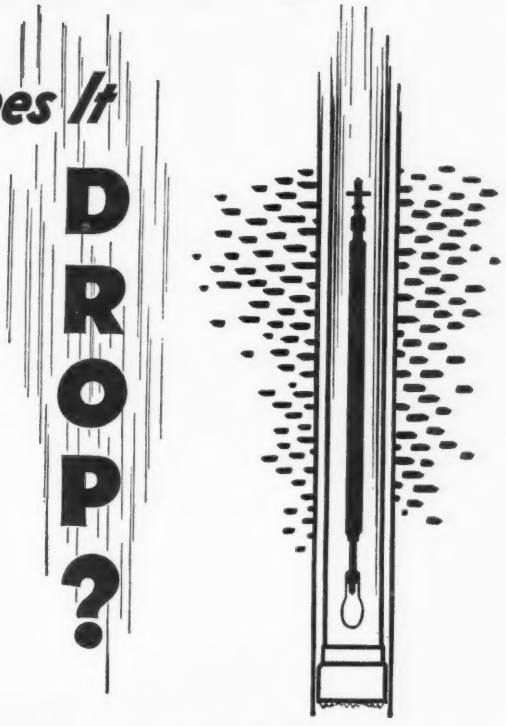

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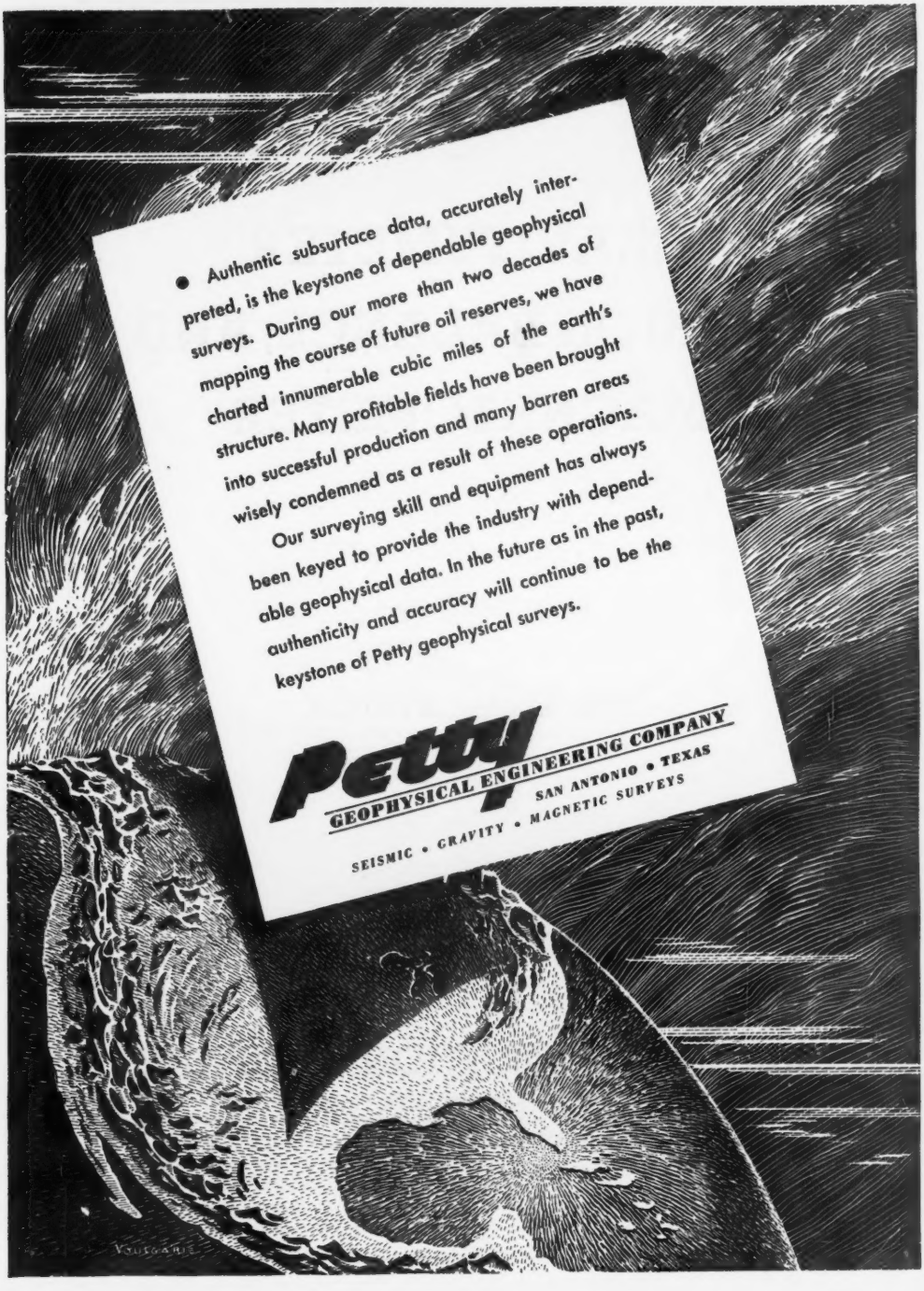
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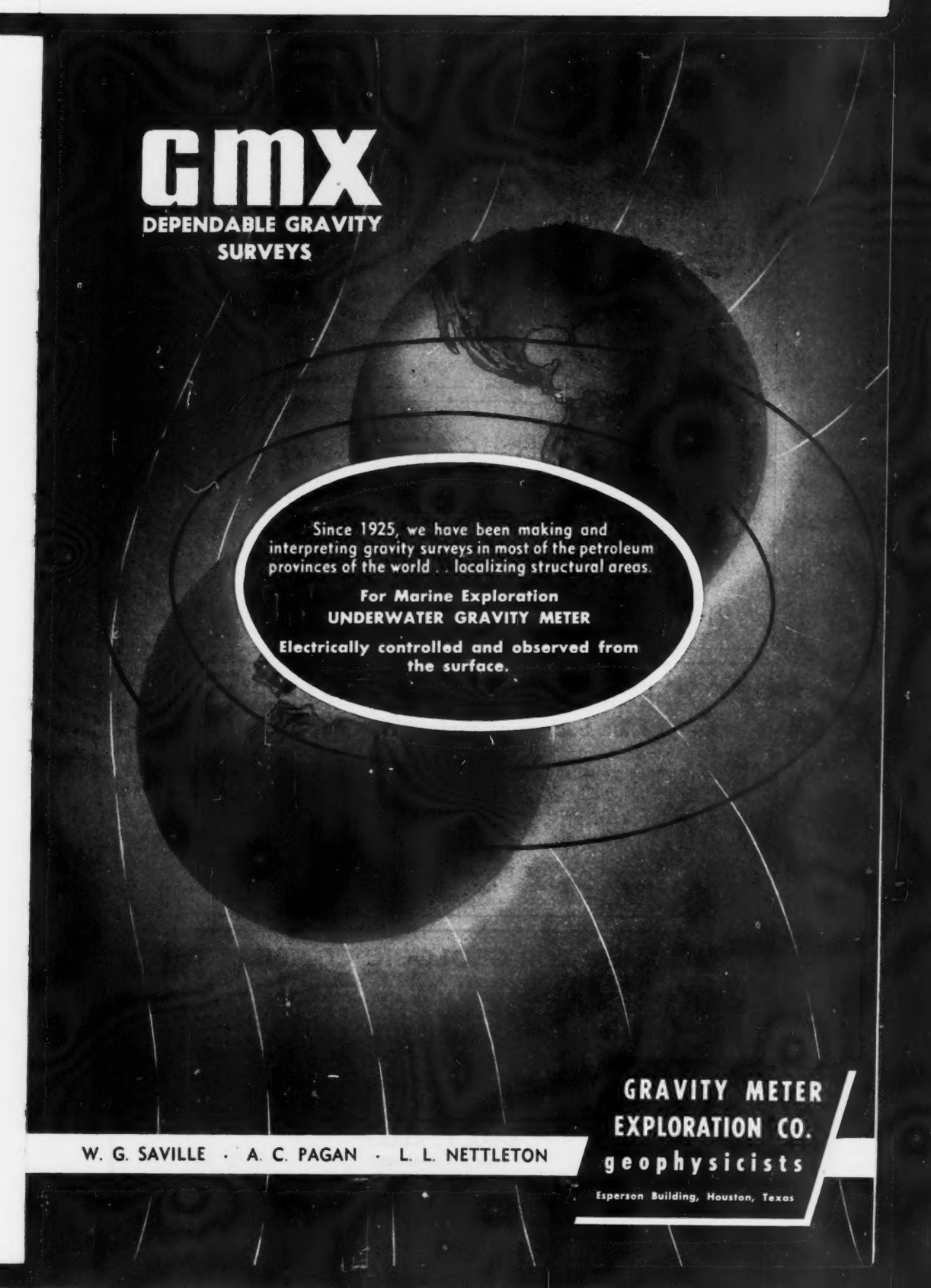
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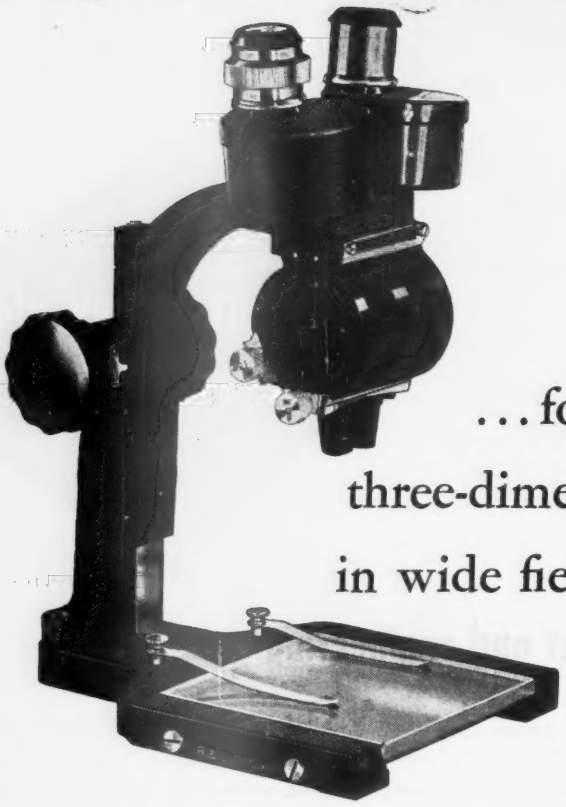

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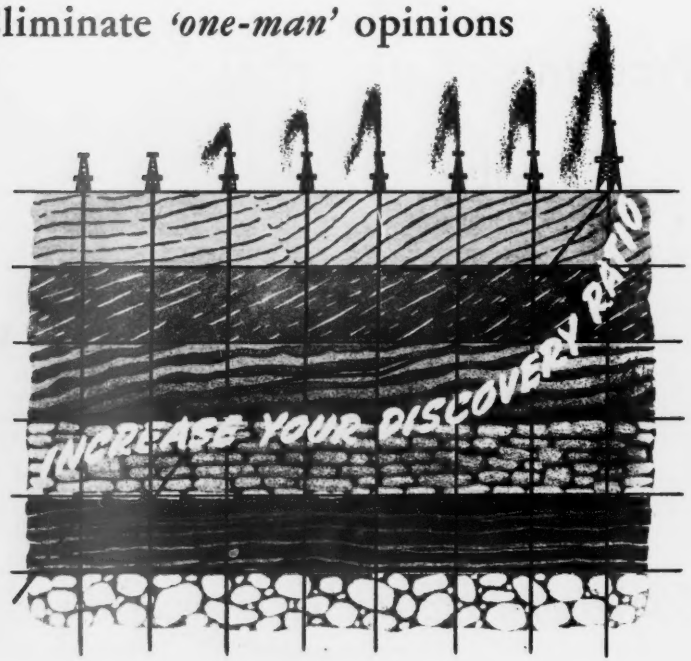

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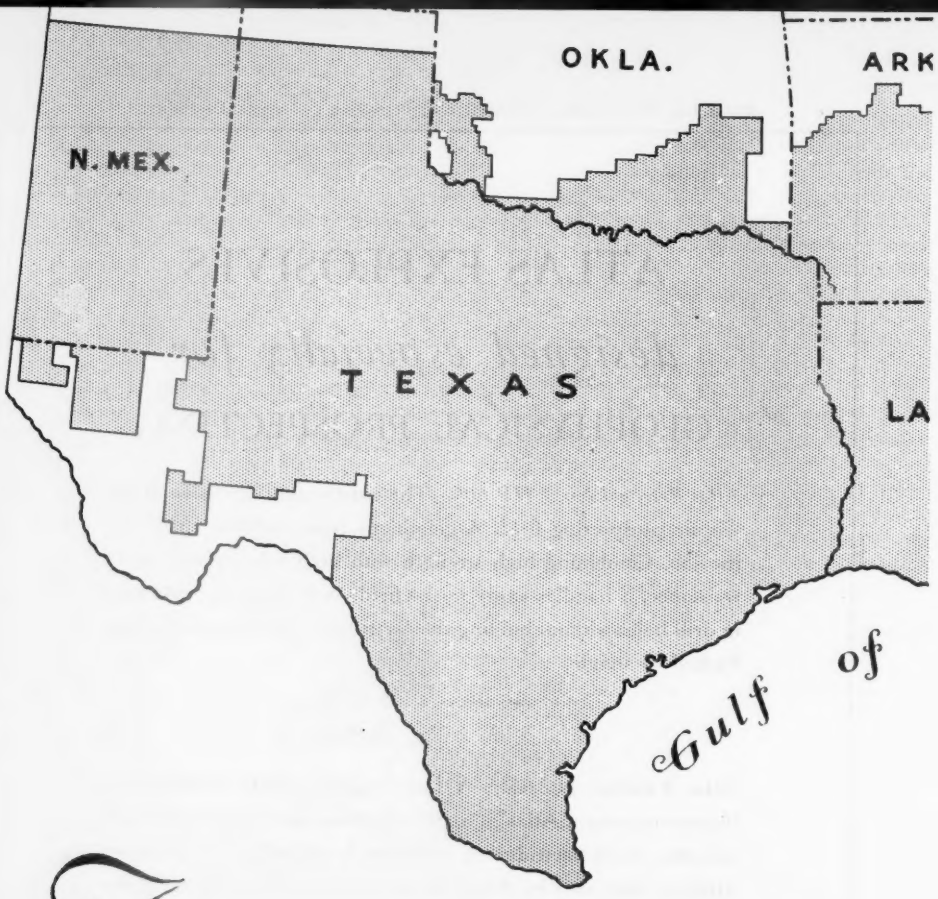

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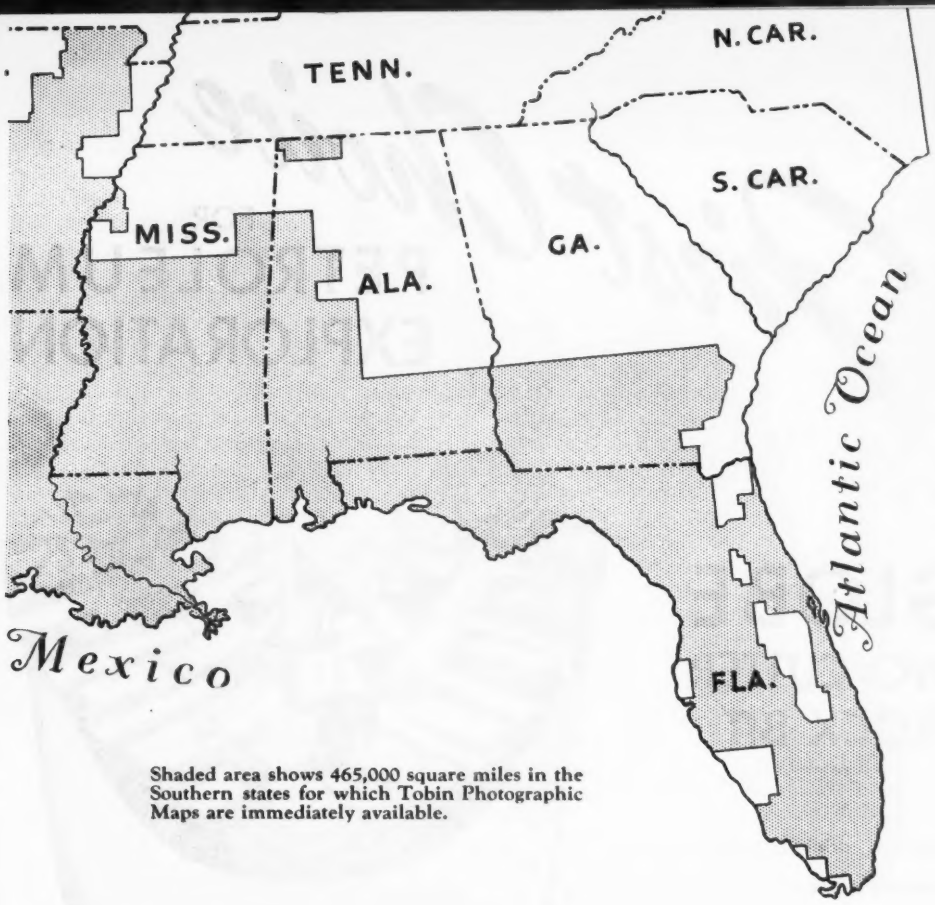

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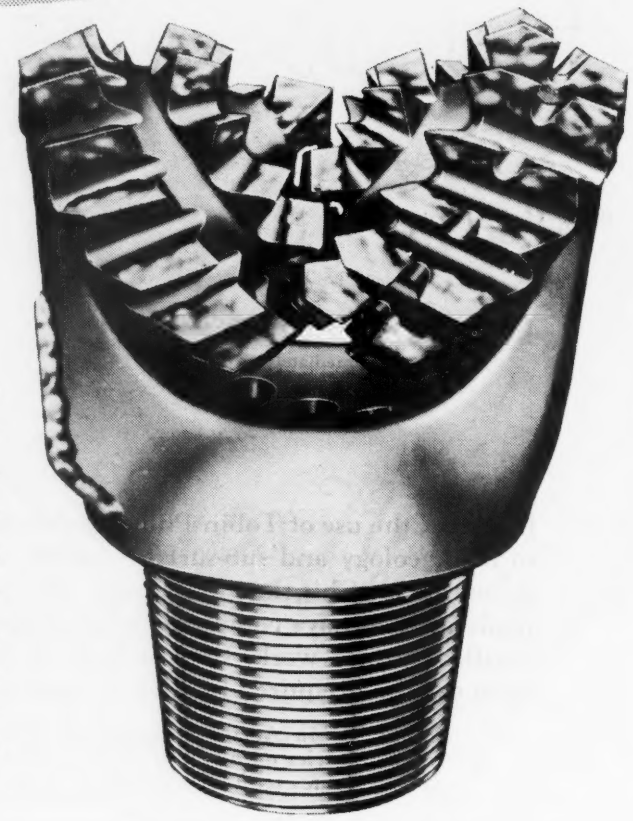

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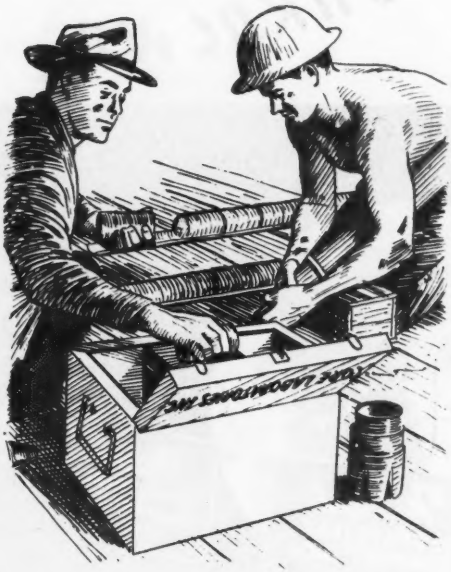

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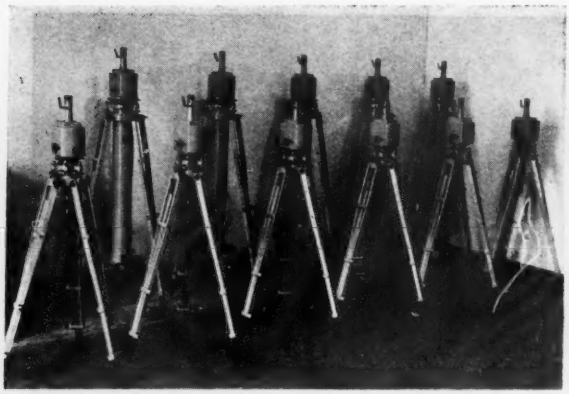

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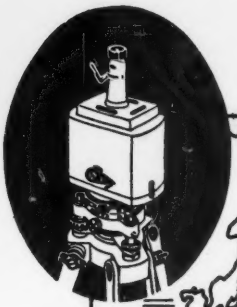

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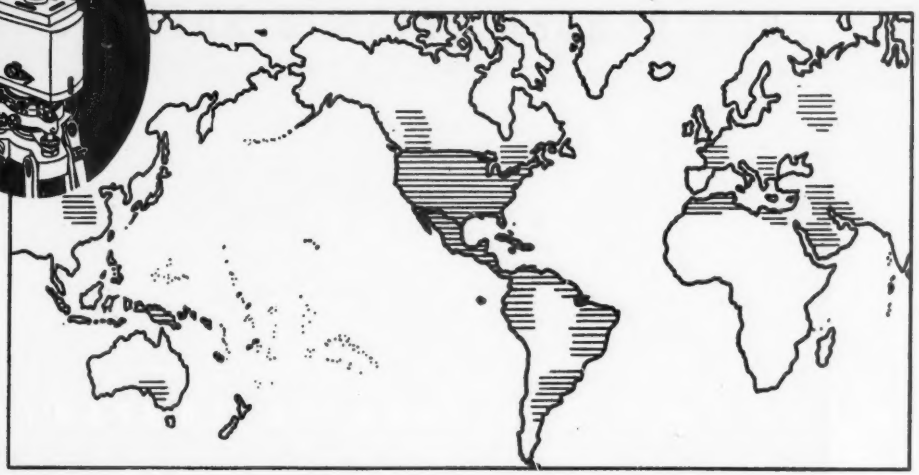

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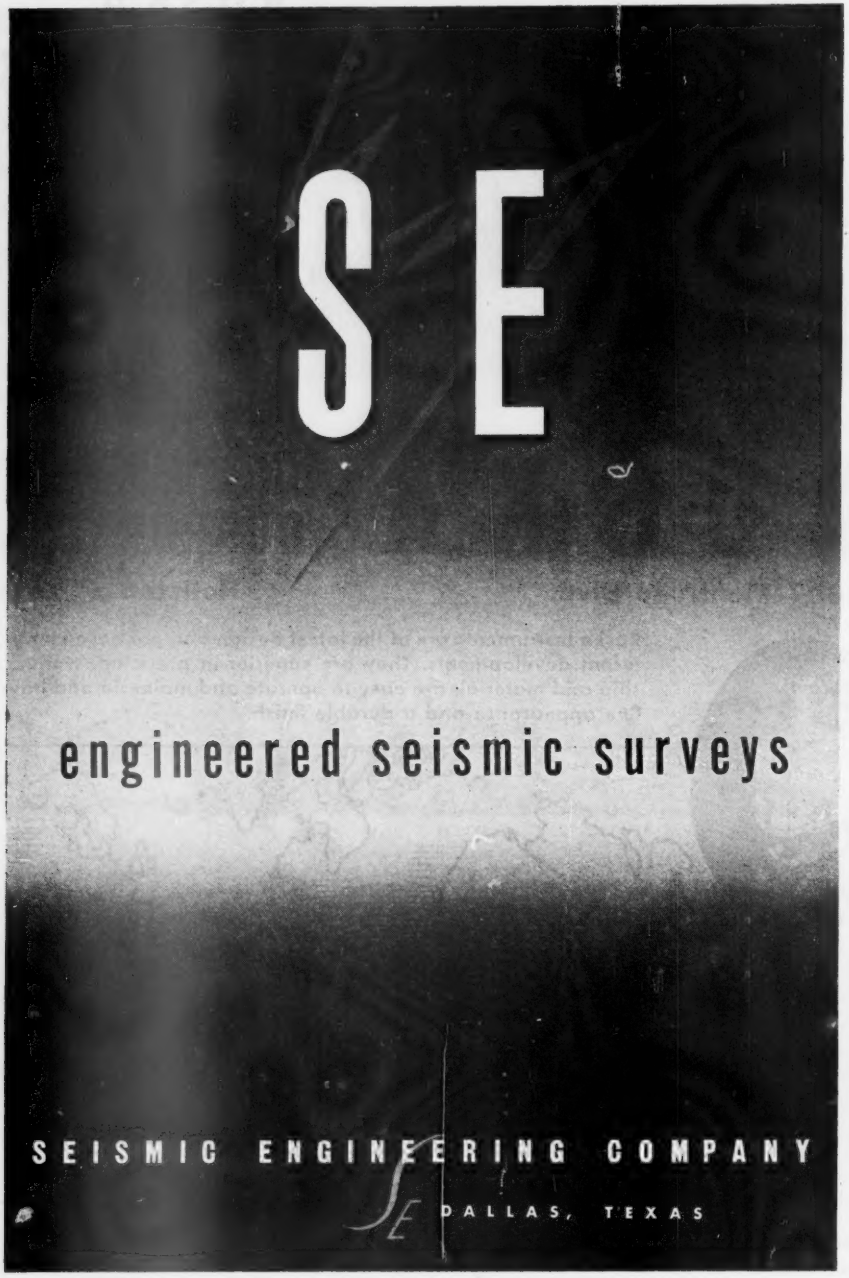
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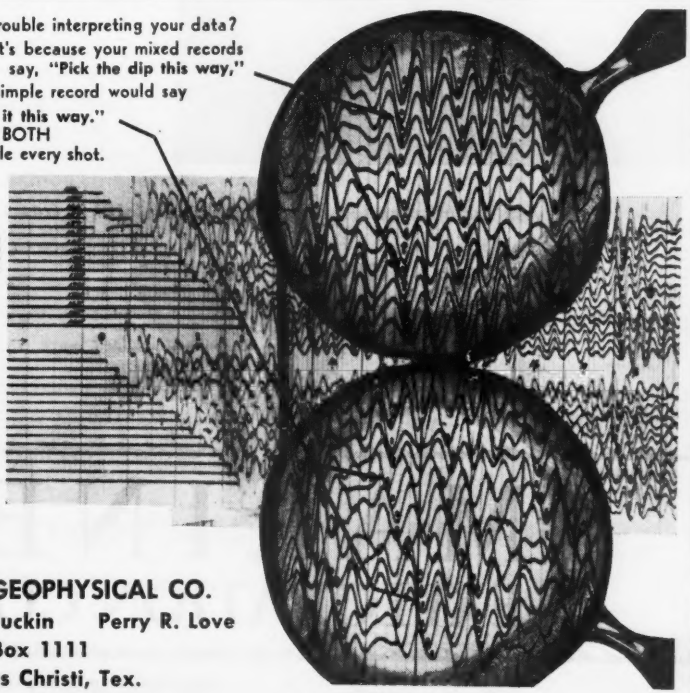

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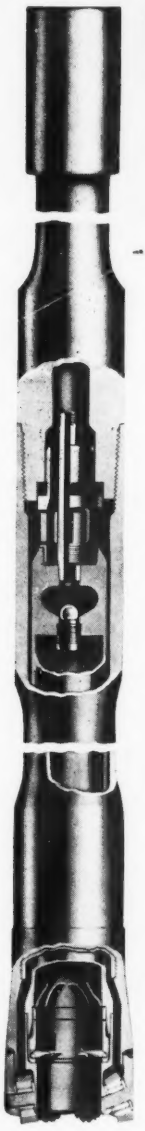

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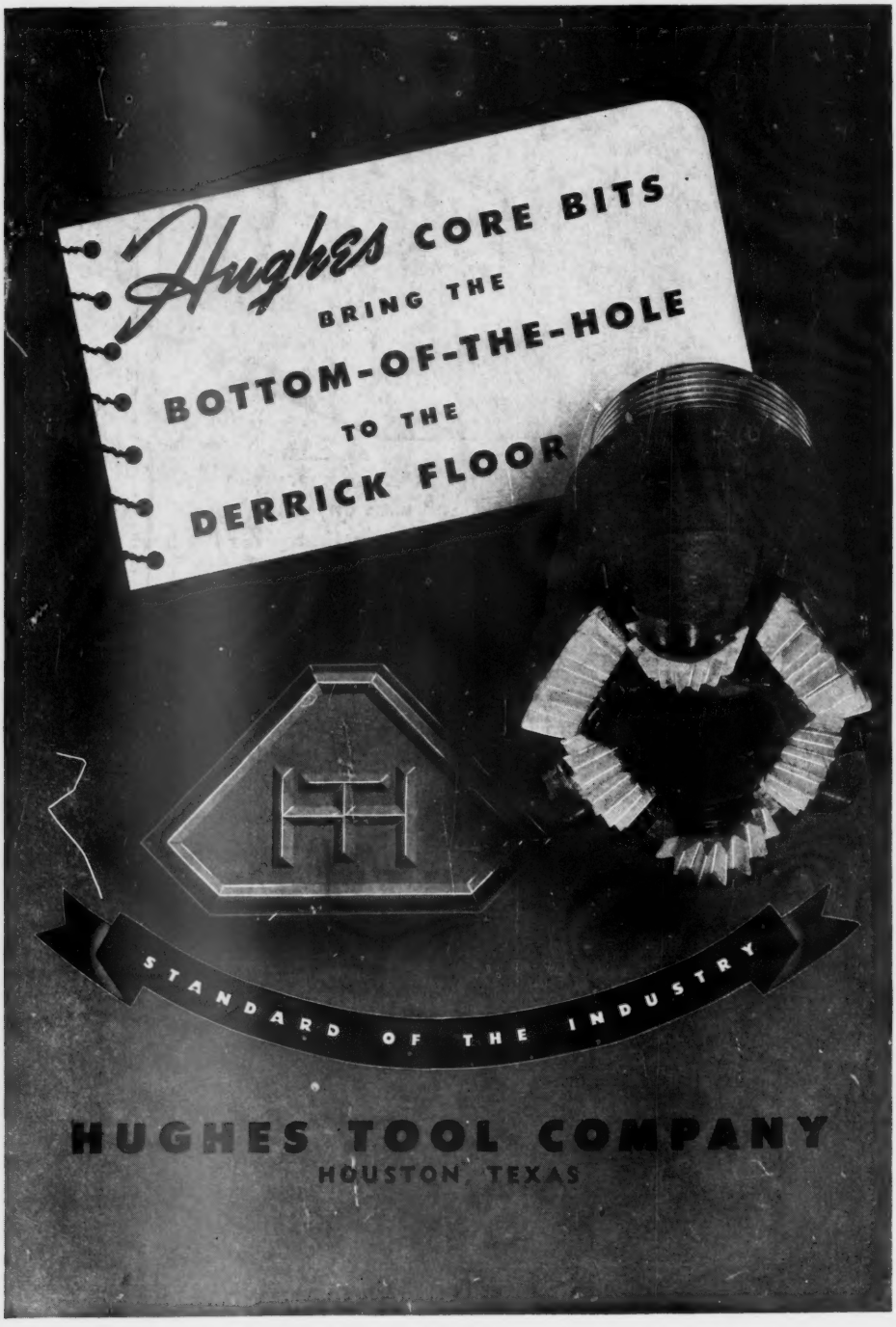
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